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Escapement Enumeration of Salmon Passing Through the Stamp Falls Fishway on the Somass River System, 1986 through 1989

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ESCAPEMENT ENUMERATION OF SALMON PASSING THROUGH THE STAMP FALLS FISHWAY ON THE SOMASS RIVER SYSTEM, 1986 THROUGH 1989

by

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ABSTRACT

Heizer, S.R. 1990. Escapement enumeration of salmon passing through the Stamp Falls Fishway on the Somass River system, 1986 through 1989. Can. Ms. Rep. Fish. Aquat. Sci. 2067:55p.

The salmon spawning escapements passing through the Stamp Falls Fishway were determined for the years 1986 through 1989. The estimates were made by video techniques in 1986 and 1987, by a combination of video and visual techniques in 1988, and by visual techniques alone in 1989. Numbers of chinook escaping increased during the years studied (1986 - 35,121, 1987 - 53,216, 1988 - 76,320 and 1989 - 79,225), while numbers of coho, sockeye and steelhead fluctuated (**coho** -- 1986 - 27,195; 1987 - 17,050; 1988 - 12,329; 1989 - 41,129; **sockeye** -- 1986 - 33,475; 1987 - 55,160; 1988 - 24,015; 1989 - 38,785; **steelhead** -- 1986 - 561; 1987 - 825; 1988 - 947; 1989 - 635). Mark incidence and sex composition data were taken for chinook salmon. Chinook sex compositions varied over the study years from 1 male:1.38 females to 5.37 males:1 female. Mark incidence for chinook varied from 1 mark:77.7 unmarked fish to 1 mark:87.3 unmarked fish.

Key words: Somass, Stamp Falls, chinook, salmon, escapement, video, visual, mark incidence, sex composition

RÉSUMÉ

Heizer, S.R. 1990. Escapement enumeration of salmon passing through the Stamp Falls Fishway on the Somass River system, 1986 through 1989. Can. Ms. Rep. Fish. Aquat. Sci. 2067:55p.

Les échappées de saumons géniteurs qui traversent la passe migratoire de Stamp Falls ont été établies pour les années 1986 à 1989. Les estimations ont été faites au moyen de technique vidéo en 1986 et 1987, d'une combinaison de techniques vidéo et visuelles en 1988, et seulement par des techniques visuelles en 1989. Le nombre de saumons quinnats de l'échappée a augmenté au cours des années à l'étude (1986 - 35 121, 1987 - 53 216, 1988 - 76 320 et 1989 - 79 225), tandis que le nombre de saumons cohos, de saumons rouges et de truites arc-en-ciel a varié (**saumon coho** - 1986 - 27 195; 1987 - 17 050; 1988 - 12 329; 1989 - 41 129; **saumon rouge** -1986 - 33 475; 1987 - 55 160; 1988 - 24 015; 1989 - 38 785; **truites arc-en-ciel** - 1986 - 561; 1987 - 825; 1988 - 947; 1989 - 635). Les données sur l'incidence des poissons marqués et sur la composition selon le sexe ont été enregistrées dan le cas du saumon quinnat. La composition selon le sexe du saumon quinnat a varié au cours des années à l'étude passant de 1 mâle pour 1,38 femelle a 5,37 mâles pour 1 femelle. L'incidence des poissons marqués dans le cas du quinnat est passé de 1 poisson marqué pour 77,7 poissons non marqués a 1 poisson marqué pour 87,3 poissons non marqués.

Mot clés: Somass, Stamp Falls, quinnat, saumon, echappée, vidéo, visuelle, incidence des poissons marqués, répartition des sexes

INTRODUCTION

In 1984 Canada and the United States agreed on a management program directed at the rebuilding of chinook salmon (Oncorhynchus tshawytsha) stocks on a coastwide basis for a 12 to 15 year period. In 1985, a treaty was signed between the governments of Canada and the United States covering Pacific salmon. This treaty was to; 1) limit the interception by each country of the other countries salmon, 2) ensure that each country received benefits equivalent to the salmon produced in its waters, and, 3) to maximize the sustainable production of salmon along the west coast of North America. A major requirement of the agreement was to build chinook salmon stocks, which have been in a state of declining abundance, to optimum levels by 1998.

Rebuilding chinook salmon stocks required special enhancement and management actions. In response to this the Department of Fisheries and Oceans (DFO) initiated the Key Streams program in 1984. The program was designed to monitor BC chinook salmon stocks with the following objectives:

1) to evaluate the stock rebuilding program;
2) to accurately estimate the escapement to the key streams;
3) to estimate harvest rates and contributions to fisheries based on an analysis of coded wire tag (CWT) data including estimates of the total escapement of coded wire tags to the system;
4) to estimate the relative contributions of hatchery and wild/natural production to the escapement; and
5) to develop the database necessary to carry out stock/recruit analysis, and compare productivity between stocks.

Key streams were chosen for extensive study based on the following criteria; a) the existence of a hatchery to supply juvenile chinook salmon for coded wire tagging; b) accessibility for field sampling; c) feasibility of fence operations; d) geographic locations with respect to other key streams such that different areas of the coast would be represented in the program; and e) the presence of a relatively large chinook salmon escapement.

The Somass River drainage, specifically the Stamp River, a major tributary of the Somass (Fig. 1) was selected as an key stream in this program. This system supports the largest chinook salmon population on the West Coast of Vancouver Island and meets all of the above criteria although installation of a fence would be costly.

As a consequence of this selection, a study was initiated in 1984 to estimate escapement of chinook salmon to the Somass River

system (Lightly et al., 1988). This study used three indices of abundance: fishway counts, dead pitch of adults, and a Petersen mark/recapture study. The results showed a river escapement in 1984 of 56,000 chinook salmon, an order of magnitude higher than previous estimates (ibid.).

This system was studied again in 1985 and 1986, but results have not been published to date. The 1986 study was done using a video camera installed in the fishway at Stamp Falls but details of the installation and methodology are not available to me.

This report will document the studies I conducted during 1987, 1988 and 1989, and will report on results of a rereading of the video tapes from the 1986 study.

STUDY AREA

The Stamp Falls Fishway is located 14.1 km upstream from tidewater on the Stamp River, which drains Great Central Lake (Fig. 1). Chinook salmon returning to spawn above this fishway are the majority of chinook salmon returning to the Somass system, and only exclude those returning to the Sproat River which at its confluence with the Stamp River (6 km downstream from the fishway) forms the Somass River. With the exception of the Sproat River stock, then, chinook salmon passing through the fishway can be considered to be the total escapement to this system.

The fishway is a bottleneck in the system and all chinook salmon must pass through it except at times when water flows allow them to circumvent the fishway by ascending the Falls. For this reason, the fishway was selected as the counting site for the study periods covered in this report.

METHODS

1987

The study period in 1987 ran from September 28 to November 17. The objectives of the study were to determine; (1) the numbers of salmon and steelhead trout (Salmo gairdneri) passing through the Stamp Falls fishway, (2) the sex composition of coho (O. kisutch) and chinook salmon, and (3) the incidence of adipose clipped chinook and coho salmon and steelhead trout. The missing adipose fin flags the presence of a coded-wire-tag (CWT) imbedded in the snout.

Salmon passing through the fishway were enumerated by means of a video camera (Panasonic WV-CD 110) installed in the fishway and aimed at an orifice at the confluence of a pair of leads installed just downstream of the upstream exit of the fishway. The leads were designed to force fish to swim through the area viewed by the camera (Fig. 2). Later, as the video tapes (made on a JVC BR9000U VCR) were read, numbers of fish going up or down the fishway were recorded. Numbers going up minus those going

down (for each category) was the net escapement of that category.

The camera ran 24 hours a day except when the video tape was changed, when the fishway was closed so as to take biological samples or to calibrate the camera (see discussion of these subjects below), during malfunctions, and when water levels were too high to allow access to the installed equipment. A gate was closed across this orifice when the camera was not running.

During the study, 127 video tapes (which recorded 8 hours of "real" time each) were generated. These tapes were viewed using a stop motion VCR identical to the one on which they were originally recorded. The tape readers recorded numbers of each species of fish, their sex, and whether they had a missing adipose fin.

Sex of fish was determined by using external characteristics as indicators. These characteristics were colour, size and shape of head.

Field crews at the fishway also attempted to tag a portion of the run with numbered Petersen disk tags pinned to the dorsal musculature of the fish. If these tags were seen during replay of the video tapes, this would be evidence that some fish went back downstream over the falls, and later reascended the fishway where they would be counted a second time. Any tagged fish going down the fishway rather than over the falls would have been recorded on the video tapes.

Floy tags were also applied at the fishway so that an independent estimate of the escapement could be made as a check on the counting techniques.

As a check on the ability of tape readers to correctly determine species, sex and missing adipose fins, a "calibration" or comparison of actual numbers of fish swimming through the fishway with those determined by reading video tapes was attempted. To this end, a trap was installed in the fishway and was operated at intervals (Fig. 2). Numbers, species and sex of fish caught were recorded and compared with fish observed on video tapes for the same period. As a check on reader bias, 12 tapes were reread by a second reader (See Appendix 2.)

1988

In 1988, escapement passing through the fishway was enumerated during the period Sept 15 through Nov 20. The execution of the project was modified considerably for this season due to limitations of the video technique experienced in 1987. Counts of fish by species were done visually by observers counting fish as they passed over a flashboard as they exited the fishway.

Video cameras were again employed in 1988, this time for slightly different purposes. Two taping sessions occurred each day, one with the camera taping from above for 2 hrs, and one from the side for 4 hrs. The overhead view tapes provided images which were measured against reference marks on the flashboard for a sample of chinook salmon lengths, and the side view tapes were

taken to determine sex and presence or absence of adipose clips.

Grids were installed to block the fishway and to force fish to swim through two chutes where they were counted as they passed over a flashboard floor in each chute ("A" in Fig. 3). Gates in the grids closed off the chutes for periods when counting was not being done. Later in the season only one chute was employed ("B" in Fig. 3). Technicians were instructed to count between dawn and dusk, the period during which there was adequate light for observations.

A video camera was employed which was mounted directly over a counting chute for the overhead view (Fig. 4), and could be moved to a mount on the side of the fishway for the side view (Fig. 3). Lee et. al. (1989) further document the details of installation and operation of the cameras and other hardware used in this project in an unpublished consultants report available at South Coast Division offices.

1989

The project ran from Sept 14 to Nov 19 in 1989, and was again modified from prior years. Results of earlier work indicated that trying to determine sex, age and mark incidence by video or visual means at best provided data of questionable accuracy, and at worst was extremely costly and erroneous. Consequently, for the 1989 enumeration, no attempt to assess sex composition, mark incidence or age composition at the fishway was made. Observers counted the numbers of salmon passing through the fishway in a counting chute identical to that employed in 1988 ("B" in Fig. 3) with a flashboard bottom, and periodically operated a trap (Fig. 5) to validate observers ability to count and speciate fish.

Observers were required to enumerate jacks as category separate from adult fish. Jacks were arbitrarily classified as fish with fork lengths of less than 520 mm. The trap was also to be operated so that scale samples and sex information could be taken from a subsample of chinook salmon of fork length less than 590 mm. These data would allow determination of whether fish in this subsample were true jacks (precocious 2-year-old males) or smaller older fish.

REREAD OF THE 1986 VIDEO TAPES

Video tapes were made in 1986 yielding results which were questioned regarding accuracy. As a consequence, these tapes were read again, and numbers of chinook salmon were increased at the expense of coho salmon as the second reading revealed that chinook salmon were incorrectly identified as coho salmon. No rationale for this change or documentation of the criteria was available, so it was decided that the tapes should be read a third time by the contractor who had done the 1987 reading and presumably had adequate expertise.

RESULTS

1987

Escapement

Net escapement estimates (Table 1) constitute the sum of all fish of a particular species (regardless of sex or marks) going up through the fishway minus the sum of all fish of the same species going down through the fishway. The "unknown" category includes all fish which could not be clearly identified as to species. Some pink salmon (O.gorbuscha) chum salmon (O. keta) and "trout" (Salmo spp.) were counted, but were numerically insignificant. Estimated net escapements including jacks were 53,216 chinook salmon, 17,050 coho salmon, 55,160 sockeye salmon, 825 steelhead trout and 2,364 unknown salmonids (Table 1).

Mark ratio

The ratio of marked (adipose clipped) to unmarked salmon passing through the fishway is shown for chinook and coho salmon and steelhead trout in Table 2. Mark ratios by sex for chinook salmon are shown in Table 3.

In 1987, tape reading was proceeding so slowly that the readers were instructed not to check for adipose marks (except for chinook salmon) partway into the run. As a consequence, mark ratios for coho salmon and steelhead trout are for the early part of the run only. The "unknown marks" category for chinook salmon includes those fish which could not be assigned presence or absence of an adipose fin but the "unknown marks" category for coho salmon and steelhead trout includes fish with presence or absence of adipose fin undetermined and all fish from the latter part of the run. Marked to unmarked ratios were 1:77.7 for chinook (1.3% marked), 1:35.6 for coho (2.7% marked) and 2.03:1 for steelhead (67.0% marked).

Sex

The sex ratio for chinook and coho salmon and steelhead trout is shown in Table 4. An "unknown" category for chinook salmon includes those fish for which sex could not be ascribed. For coho salmon and steelhead trout, "unknown" includes, as well, all fish later in the run as the readers were instructed not to check for sex of these species in the interest of getting the tapes read quickly. As for marks, then, sex ratios for coho salmon and steelhead trout are for the early part of the run only. The ratios of males (not including jacks) to females were 5.37:1 for chinook (84.3% males), 1.25:1 for coho (55.6% males) and 0.85:1 for steelhead (45.9% males).

Timing

Fig. 6 shows the timing of chinook salmon males, females and jacks passing through the Stamp Falls Fishway for 1986-1989. Fig. 7 shows the timing of coho salmon, Fig. 8 shows the timing of steelhead trout and Fig. 9 shows the timing of sockeye salmon for 1986-1989.

Tags

A total of 70 Petersen disc tags and 58 Floy tags were applied by observers. Tagging was not successful as water temperatures were high and chinook salmon were badly stressed during tagging operations. Concerns about mortality induced by tagging led to the cancellation of this aspect of the study. Of the tags applied, 16 Petersen tags and 13 Floy tags were recovered at the Robertson Creek hatchery. None were seen in the video tapes. No attempt was made to search for tags in the river.

Discussion

Other species - The numbers of sockeye salmon passing through the fishway was surprising. Sockeye salmon returning to the Somass system are counted using Pulsar conductivity counters (Pulsar Electronics, 533 Bournemouth Cr., N. Vancouver, BC V7H 2G4), one in the fishway on the Sproat River and one in the fishway at the dam at the exit of Great Central Lake (Fig. 1). These counters are removed before the chinook salmon migration as the counting tunnels are too small for chinook salmon to pass through.

Sockeye salmon returns to the Somass system were estimated to be 298,322 in 1986; 376,870 in 1987; 430,196 in 1988 and 403,453 in 1989 (Dr. Kim Hyatt, pers. comm.). Sockeye salmon counted during the Stamp Falls project are not included in these estimates, yet constitute significant percentages of the total return (11.2% - 1986, 14.6% - 1987, 5.6% - 1988 and 9.6% - 1989).

Error - There are errors associated with counting, with sex determination, and with species determination. Appendix 2 contains a discussion and analysis of error in this study.

The calibration attempts indicate that the video method of counting chinook salmon provides estimates with an error of approximately +/- 10%. Rereading the tapes a second time suggests that there is no significant reader bias, but the rereading design was faulty and did not allow a fish by fish comparison; hence, species identification biases were not able to be assessed. The total count (all tapes summed) is remarkably similar (1% difference) but the absolute relative difference, comparing tape to tape, was much larger (16.5% for chinook salmon): Errors appear to have cancelled.

Results of the error analysis conclude that the videotaping technique provides reasonable counts of chinook salmon through the fishway. The analysis further concludes that the technique is not recommended for assessment of sex ratios or marked to

unmarked ratio. Data reported here has not been adjusted for bias or error.

1988

Escapement

Video tapes taken in 1988 were examined in a laboratory and length, sex and mark data were recorded, then summarized. Table 1 presents results of the visual counts of fish passing through the fishway. Estimated net escapements including jacks were 76,320 chinook salmon, 12,329 coho salmon, 24,015 sockeye salmon, 947 steelhead trout and 1,592 unknown salmonids.

Mark ratio

A random subsample of the side view tapes (43 of the 53 tapes made were read due to time and financial limitations) was examined for mark incidence. Table 2 presents these results. Marked to unmarked ratios were 1:87.3 for chinook salmon (1.1% marked), and 1:61.5 for coho salmon (1.6% marked). No marked to unmarked ratios were estimated for steelhead trout. Mark ratios by sex for chinook salmon are shown in Table 3.

Sex

The subsample of side view tapes, used for determining mark incidence, was also viewed for sex composition. Table 4 presents these results. Sex ratios (M:F) were 1:1.38 for chinook salmon (42.0% males)and 1:1.68 for coho salmon (37.3% males).

Length

A random subsample of the top view video tapes (13 of the 34 tapes made were read due to time and financial limitations) was examined and a length-frequency histogram plotted (Fig 10). This plot implies age composition: The first peak is likely 3-year olds, the second a mixture of 4- and 5-year olds.

Timing

Figs. 6, 7, 8 and 9 show timing of, respectively, chinook salmon, coho salmon, steelhead trout and sockeye salmon through the Stamp Falls Fishway during the 1988 study.

Discussion

Error - Attempts to quantify and control error and bias in estimates of escapement, sex ratios and age compositions included:

1. comparisons between readers reading the same tapes;

2. comparisons between field counts and tape counts including effects on total counts, species and sex identification;
3. identification and quantification of bias in determinations of sex and length.

These elements are dealt with in some detail in Lee et al. (1989). The between reader comparisons show that, as in 1987, the total counts are quite similar (mean for the test tape was 418 salmon, with a standard deviation of 8.98 and covariance of 2.15) but that species counts, and more particularly sex determination counts vary considerably. In all probability, sex composition data should be ignored from 1987 and 1988 as it appears that the video taping method is not a reliable technique for sex determination. It is, however, included here in the interest of completeness.

Length measurements suffered from three sources; (1) the accuracy and precision of the measurements inherent in set-up in the fishway, (2) bias introduced through parallax (due to the fish being closer to the camera than the reference lines on the flashboard), and (3) bias due to the exclusion of large fish from the length samples. The exclusion of large fish occurred as some chinook salmon (those larger than 950 mm.) did not always fit entirely in the viewing window in a single frame of the tape, and the computer software employed to measure and record the lengths was unable to accommodate by taking lengths from multiple tape frames.

Accuracy was tested by replicate measurements of a known point-to-point distance and was determined to be +/- 7 mm in 500 mm (that is, 1.4%). This was done for replicates of the 500 mm index mark on the flashboard from the same video frame, and also for similar measurements of the index lines from different frames. The mean was within 1 mm of the true value, and had 95% confidence limits of less than 5 mm.

Mean bias due to parallax was calculated to be +3% for length measurements thus a correction factor of .97 x biased length should be employed for lengths taken in 1988.

Bias due to exclusion of larger fish was calculated by using measuring software which was able to take lengths from multiple frames. This development came too late to be used for the whole of the 1988 season. Table 5 shows calculated proportional multipliers by size class which should be applied to the initial biased sample sizes. Length data in Fig 10 and the text discussion have <u>not</u> been corrected for this bias.

1989

<u>Escapement</u>

Table 1 shows the net escapement past the Stamp Falls fishway in 1989. Linear interpolations were made for periods during which no counts could be made. A total estimated net

escapement for chinook salmon should also include 3,141 chinook salmon mortalities found in the area below Stamp Falls and sampled by staff from the Robertson Creek hatchery. This total is 82,366 including jacks, or 79,225 live chinook salmon through the fishway plus 3,141 mortalities. There were, as well, 41,129 coho salmon (including jacks), 38,785 sockeye salmon, 635 steelhead trout and 1398 unknown salmonids.

Sex

Table 6 documents sex information taken at the time the mortalities below Stamp Falls were examined.

Other sex information

During the season, Robertson Creek hatchery staff noticed a disproportionate male to female ratio in the escapement of chinook salmon to the hatchery (7:1). Consequently, fishway observers recorded their assessment of numbers by sex on 24 days between Oct 20 and Nov 19. Of the 5,313 chinooks counted during this period, 1,734 (32.6%) were females (see App. 1, Table 8.) The final sex ratio for chinook in the brailer at Robertson Creek Hatchery was 4.66:1 or 82.3% males (Paul Starr, pers. comm.)

Mark ratios

Mark ratios were not determined for the 1989 study.

Timing

Figs. 6, 7, 8 and 9 show, respectively, timing of chinook and coho salmon, steelhead trout and sockeye salmon through the Stamp Falls Fishway during the 1989 study. Linear interpolations were made for periods during which no counts could be made. These periods were: 1) October 23-28 due to high water conditions, and 2) November 14 and 15 when a prototype video counter was tested. This correction was done only for the 1989 data.

Discussion

Attempts were made to quantify errors associated with counting and speciation, but the trapping apparatus designed for this aspect of the study could not be effectively operated without significant modification to both the trap and the fishway.

In spite of this, seven calibration trappings were conducted. Two of these attempts were invalid as the area between the trap and the chute was not tight and some fish were able to escape. Four calibrations indicated no error, and during one calibration, the observer incorrectly identified a coho as a chinook jack. In 5 of the seven calibrations, no counting error occurred. These data are not conclusive, but do indicate that

observer accuracy can be high under good viewing conditions.

Only one sample of small chinook salmon was trapped to determine observer accuracy in correctly identifying chinook salmon jacks. The sample size was too small and did not cover the appropriate size range. Information from Robertson Creek hatchery reported to the contractor (Wright, 1990) indicates that less than 1% of chinook salmon sampled in the 52.1-59.0 cm range are jacks, and that all chinook salmon with fork lengths of less than 52.0 cm are jacks.

1986 REREAD

Escapement

Estimated net escapement of chinook, coho and sockeye salmon and steelhead trout passing through the Stamp Falls Fishway in 1986 are shown in Table 1. Estimated net escapement was 35,121 chinook salmon, 27,195 coho salmon, 33,475 sockeye salmon, 561 steelhead trout and 14,862 unknown salmonids. The large number of unknown salmonids was due to very poor video images on the 1986 tapes.

Mark ratio

Only chinooks were examined for marks. The marked:unmarked ratio for all chinook salmon was 1:79.6 or 1.2% marked (Table 2.) Table 3 shows the mark ratio by sex.

Sex

Chinook salmon were also examined for sex. The sex ratio (males:females) was 1.06:1 (51.5% males), not counting jacks (Table 4).

Timing

Figs. 6, 7, 8 and 9 show, respectively, timing of chinook salmon, coho salmon steelhead trout and sockeye salmon through the Stamp Falls fishway during the 1986 study.

DISCUSSION OF 1986 THROUGH 1989 RESULTS

Fishway count estimates of escapement are subject to error as discussed in the sections above dealing with each years design and results.

There are, as well, several additional sources of error which contribute to an underestimate of abundance for each species:

1. An unknown number of fish undoubtedly bypass the fishway completely under certain water flow conditions. It is virtually impossible to assess the degree to which this occurs, but there

are field observations which indicate that under certain conditions, this may be a significant source of error. During the 1989 season, observers noticed large numbers of chinook salmon in the pool below the falls. After the flood of Oct 23-26, during which time hydraulic conditions were suitable for bypass, observers noted a dramatic decline in numbers of chinook salmon in this area.

Observers have witnessed chinook salmon successfully negotiating the falls, and it is likely that the fish seen in the pool below the falls went upstream over the falls during the flood. For the 1989 season, this could have amounted to thousands of chinook salmon.

2. Migration of fish through the fishway both before and after installation of the counting apparatus will also contribute to an underestimate of abundance.

3. There are periods when fish are passing through the fishway and no counts can be obtained. The counting chute required periodic adjustment due to fluctuating water levels, and during these brief periods, fish are able to move through the counting station unenumerated. A combination of turbid water and high flows during the video counting studies allowed fish to pass through the fishway when water was so turbid no filming was possible and flows made it impossible to shut the gate in the grates. This was usually dealt with by extrapolating over the period in question, but this remedy was not appropriate for those situations where the beginning time of a malfunction was unknown.

Errors associated with items 2. and 3. above are likely not large. Migration prior to startup might be controlled by starting the project on September 1 and assessing the extent of the problem. Unknown leaks of fish past the hardware in the fishway might be controlled by modification of the equipment installed. Both of these remedies will be expensive.

The problem of fishway bypass, however, is likely both significant and next to impossible to quantify or remedy. One person involved with the project suggests that some sort of electronic barrier fence installed at the base of the falls might be an effective way of insuring that all fish would be diverted through the fishway.

RECOMMENDATIONS

If similar escapement estimation studies are to continue on the Somass River system, I believe that several modifications at Stamp Falls will be required:

1. Because of the bypass problem, some sort of barrier should be designed which would force all salmon to pass through the fishway. This could take the form of the electronic barrier fence mentioned above. Stamp Falls is a popular site for tourists and such a provision could be dangerous to the

inquisitive. Moreover, there is no electric power to the site at present and such a provision would be costly.

2. Some method of keeping fish from passing through the fishway during floods (when they cannot be seen) should be developed. This might be achieved by shutting the downstream entrance to the fishway during these periods. This option may increase fish mortalities, however.

3. If video means are employed to count fish, some way must be devised to restrict fish passage past the camera to a rate which yields little or no overlap of fish passing through the viewing area of the camera. As well, the fish will have to be forced to present themselves in a proper orientation to the camera so as to optimize image quality. An appropriately designed chute should remedy this. Adequate artificial lighting will have to be installed. All hardware installed in the fishway will have to be redesigned and constructed so that it is suitably substantial and can be easily accessed and moved during a variety of hydraulic conditions.

4. Due to the high cost of reading video tapes, computer software with the capabilities of discriminating between sexes, and which can determine lengths and presence/ absence of fin clips directly from video tapes could be developed. The costs of this would, however, likely be prohibitively high.

5. It is possible that with encouragement, the prototype video fish counter being developed by RETECH, (Retech, 627 John St., Victoria BC - Michael Roch) and tested at Stamp Falls in 1989, may remedy (3) and (4), but likely will be expensive.

6. If observers are to visually count fish passing through the fishway, then proper chutes which can be raised and lowered for different water levels and which remain "fish tight" will be required. As well, a trap which can operate easily under a variety of hydraulic conditions will be required to do calibrations and validations so as to assess errors and provide live fish for sampling as required. These traps might be designed along the lines of that used in the fishway at Great Central Lake.

7. It is not possible to determine whether the video method is in any way superior to the field observation method since there is no way to determine <u>actual</u> numbers of fish passing through the fishway. In my judgement, the simpler and less expensive method of field counting salmon is the most reasonable method.

ACKNOWLEDGEMENTS

I would like to thank Jim Mitchell, Senior Management Technician, and the staff of Robertson Creek Hatchery for their generous and excellent assistance in the execution of this project. As well, I appreciate the reviewers of this document (Rick Semple, Mike Wright and Paul Starr) for their useful and insightful comments.

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FIGURES

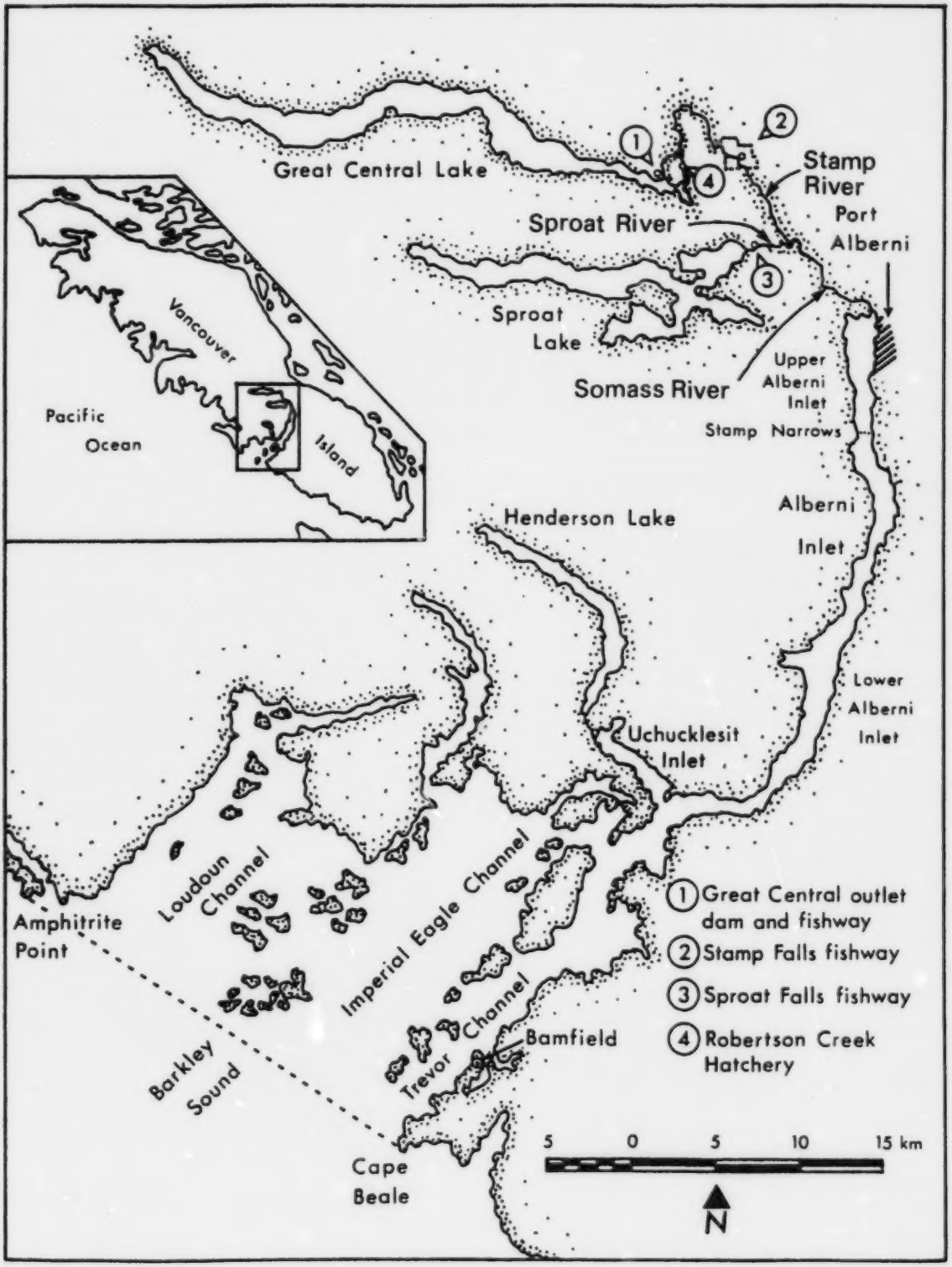

Fig. 1. Stamp Falls Study Area, Alberni Inlet and Barkley Sound.

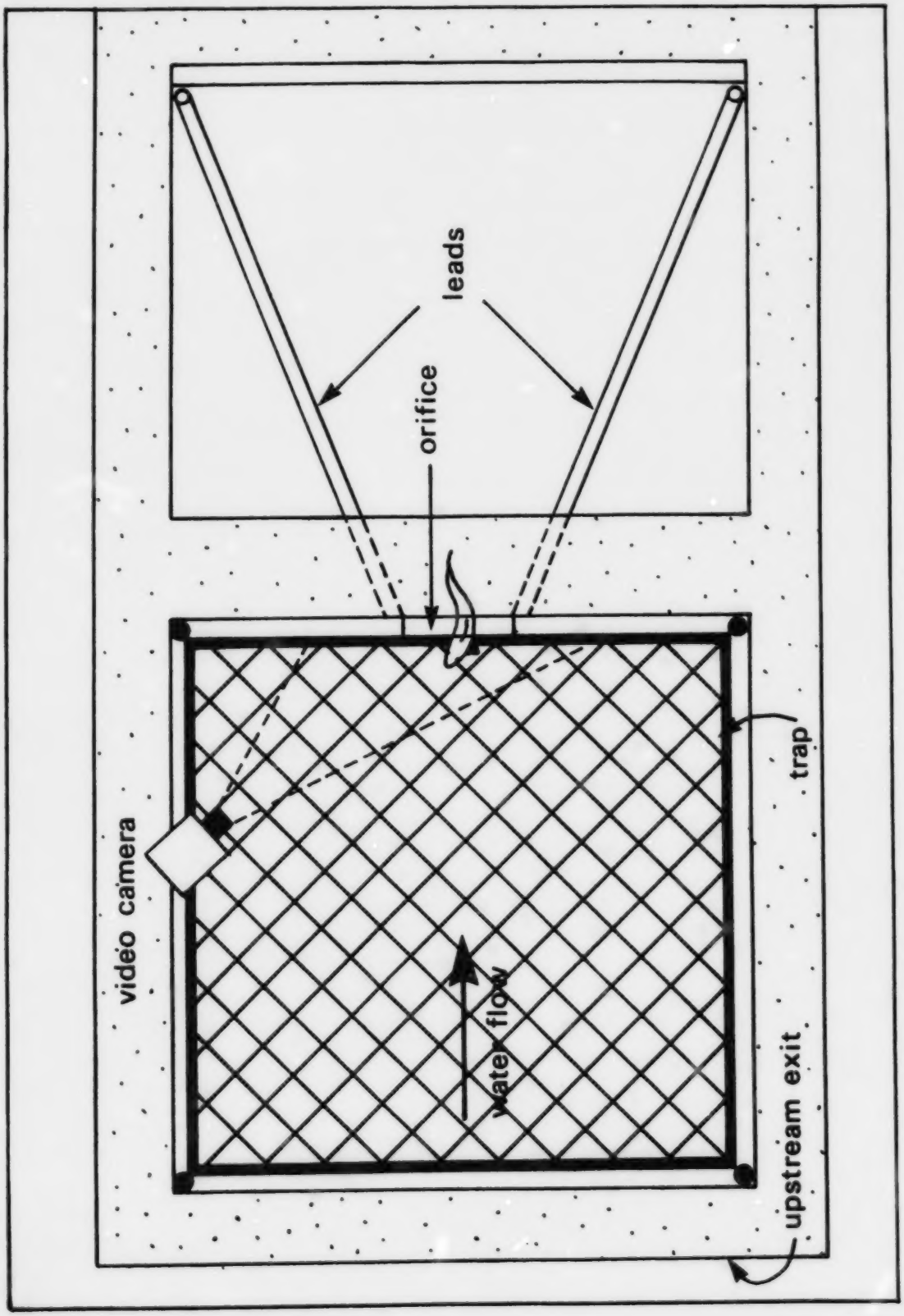

Fig. 2. Overhead view of the fishway at Stamp Falls, showing leads, orifice, camera and trap configuration used in the 1987 study.

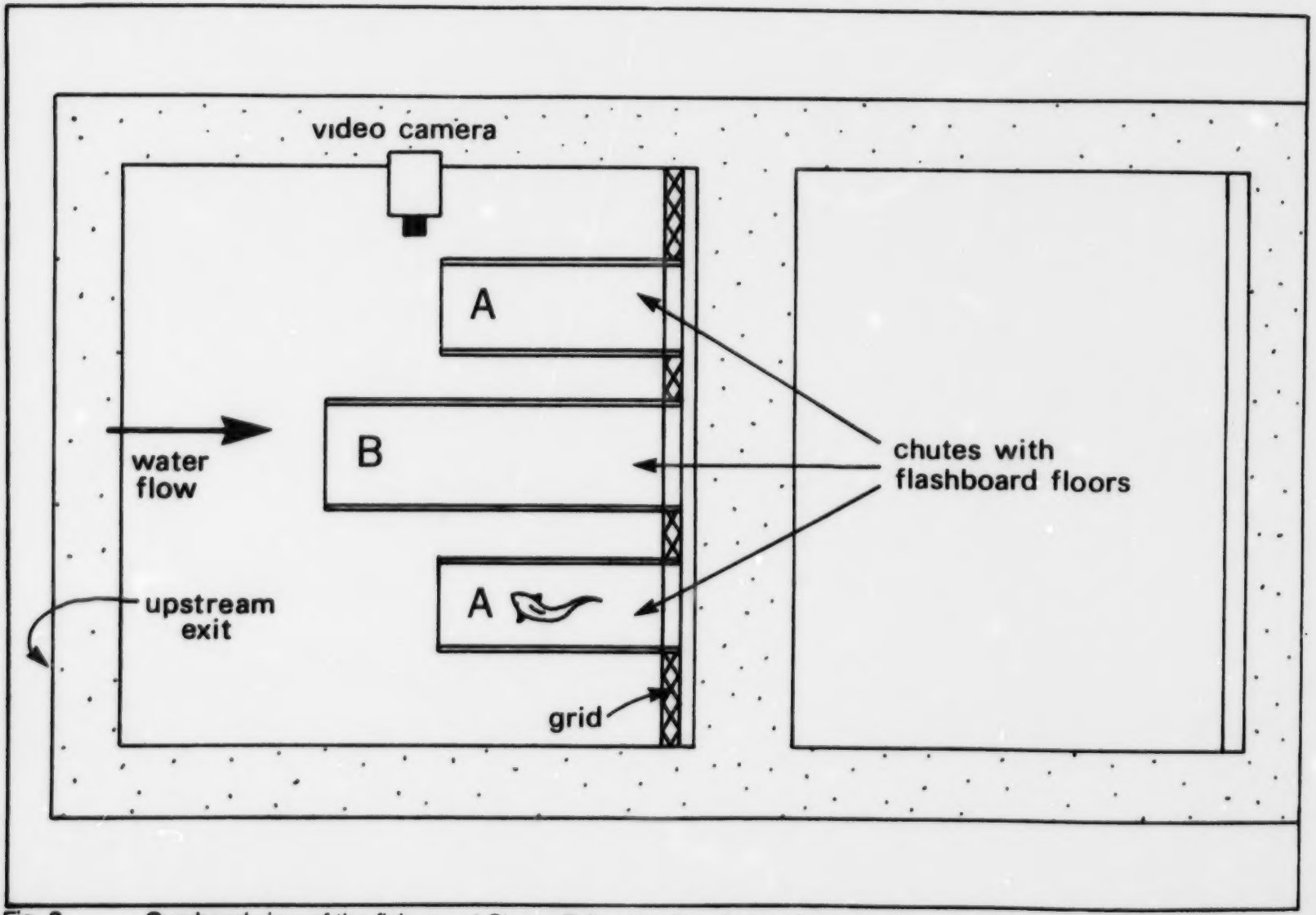

Fig. 3. Overhead view of the fishway at Stamp Falls showing chutes, flashboards, grid and camera used in the 1988 and 1989 study.

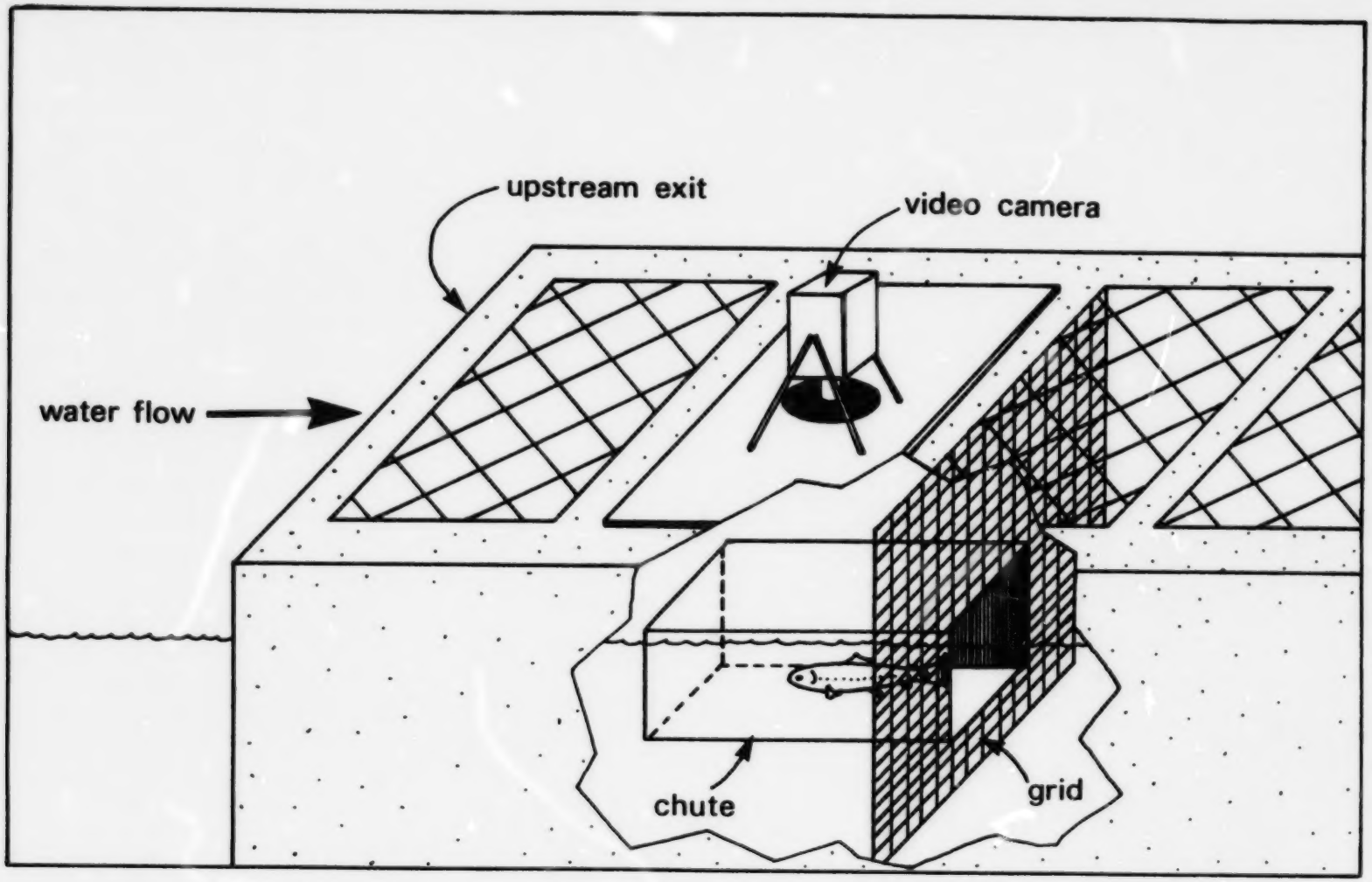

Fig. 4. Side view of the fishway at Stamp Falls showing chute and overhead camera used in the 1988 study.

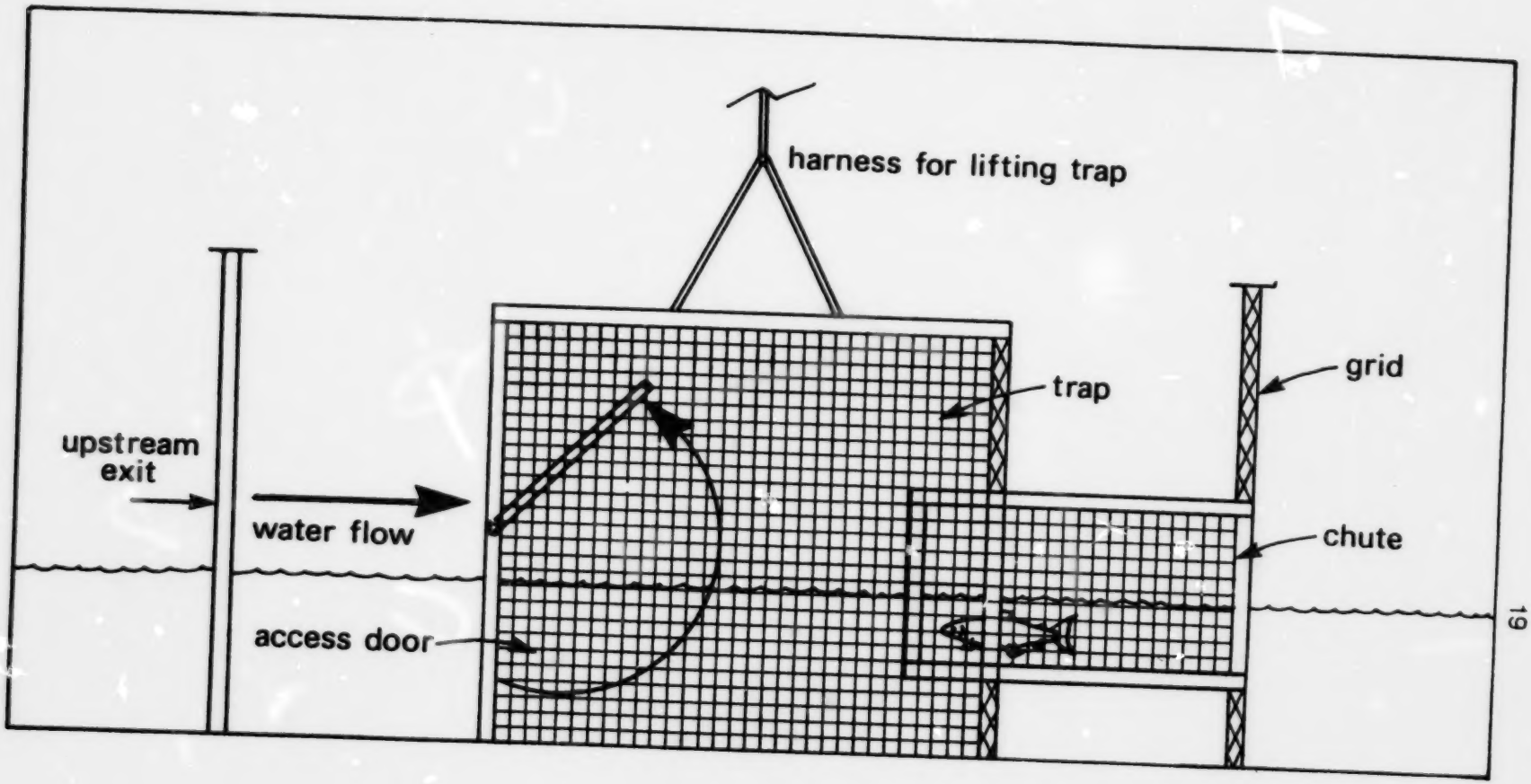

Fig. 5. Side view of the fishway at Stamp Falls showing trap and chute configurations used in the 1989 study.

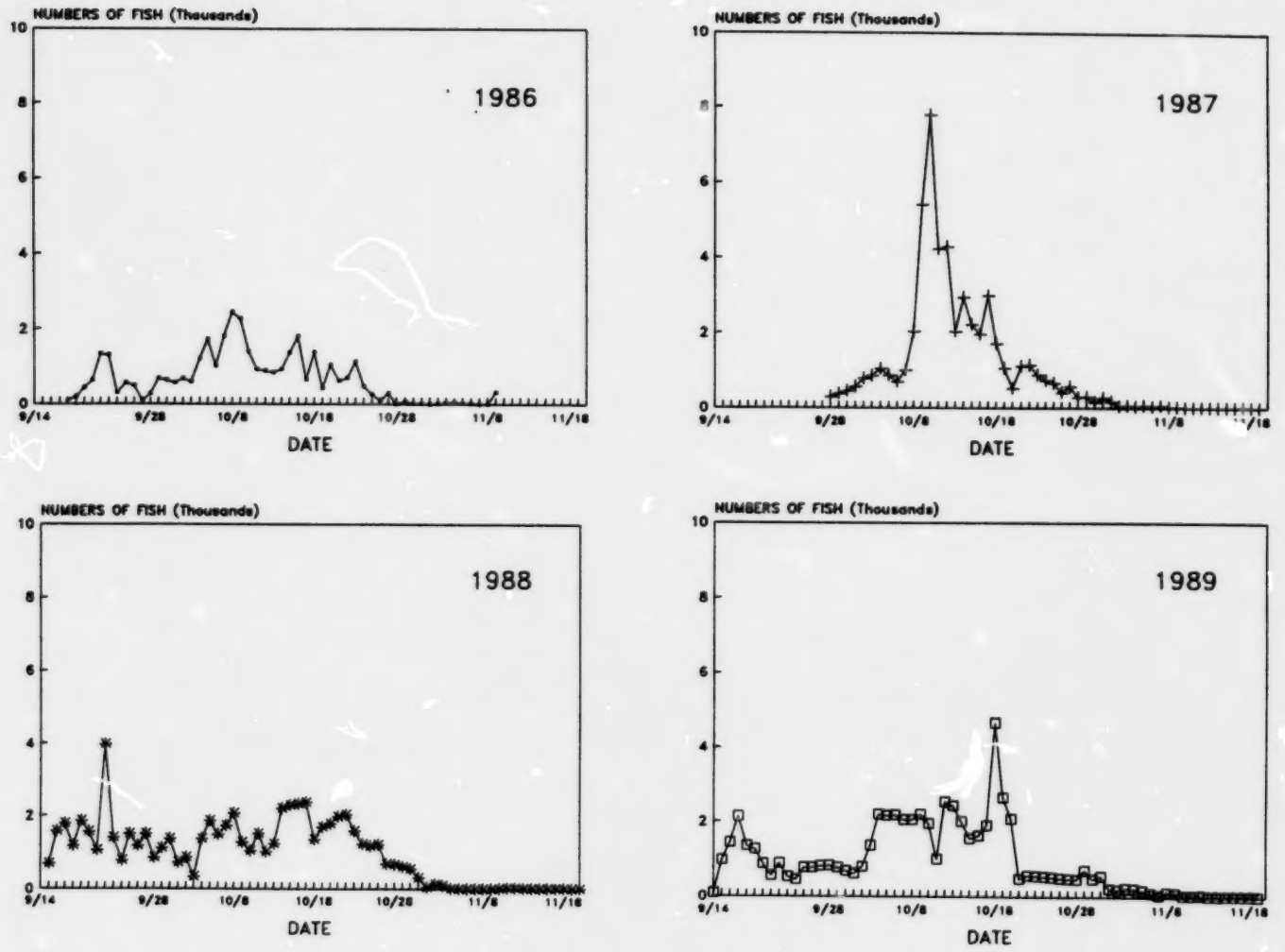

Fig. 6. Timing of chinook salmon through the Stamp Falls fishway, 1986 through 1989.

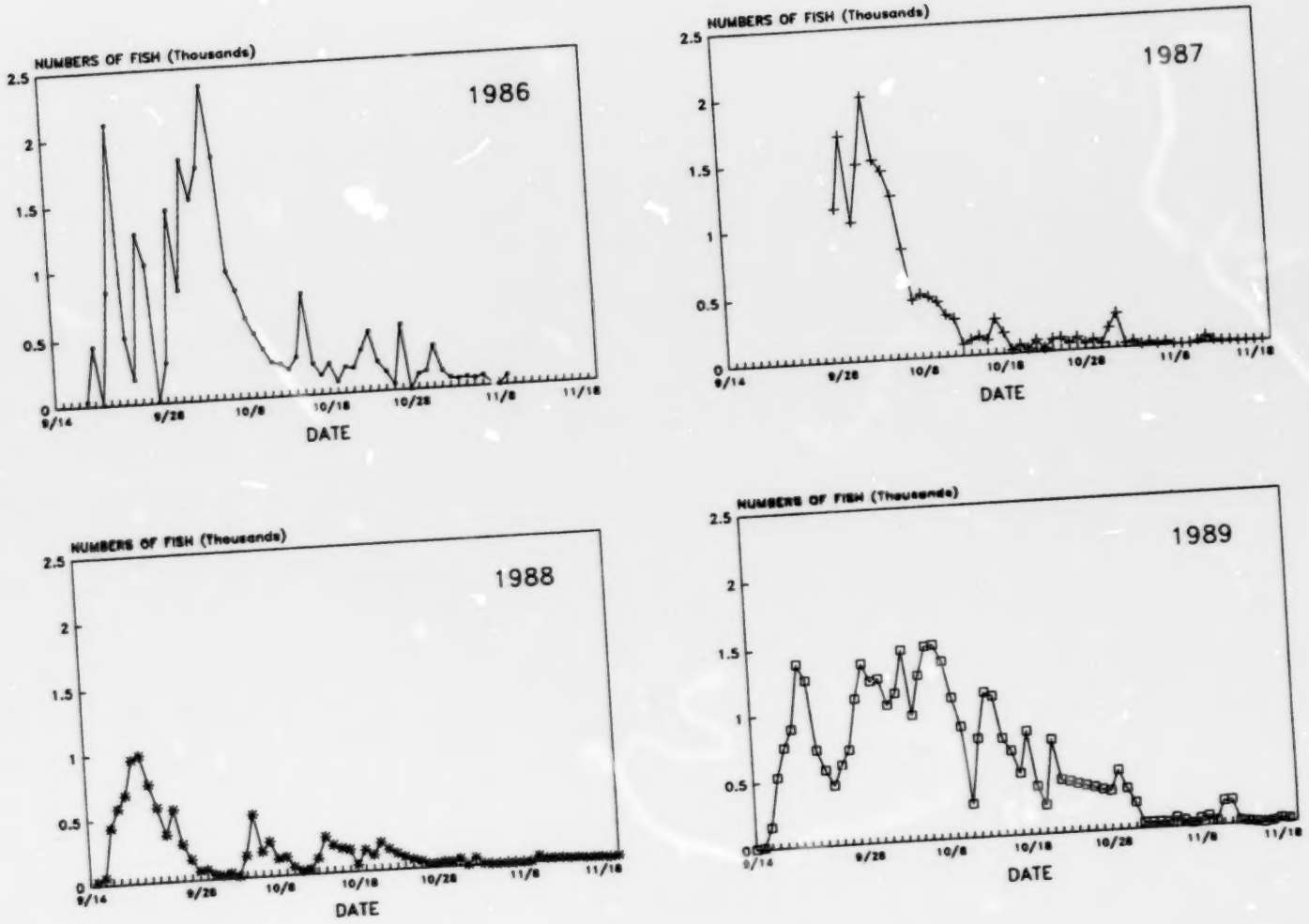

Fig. 7. Timing of coho salmon through the Stamp Falls fishway, 1986 through 1989.

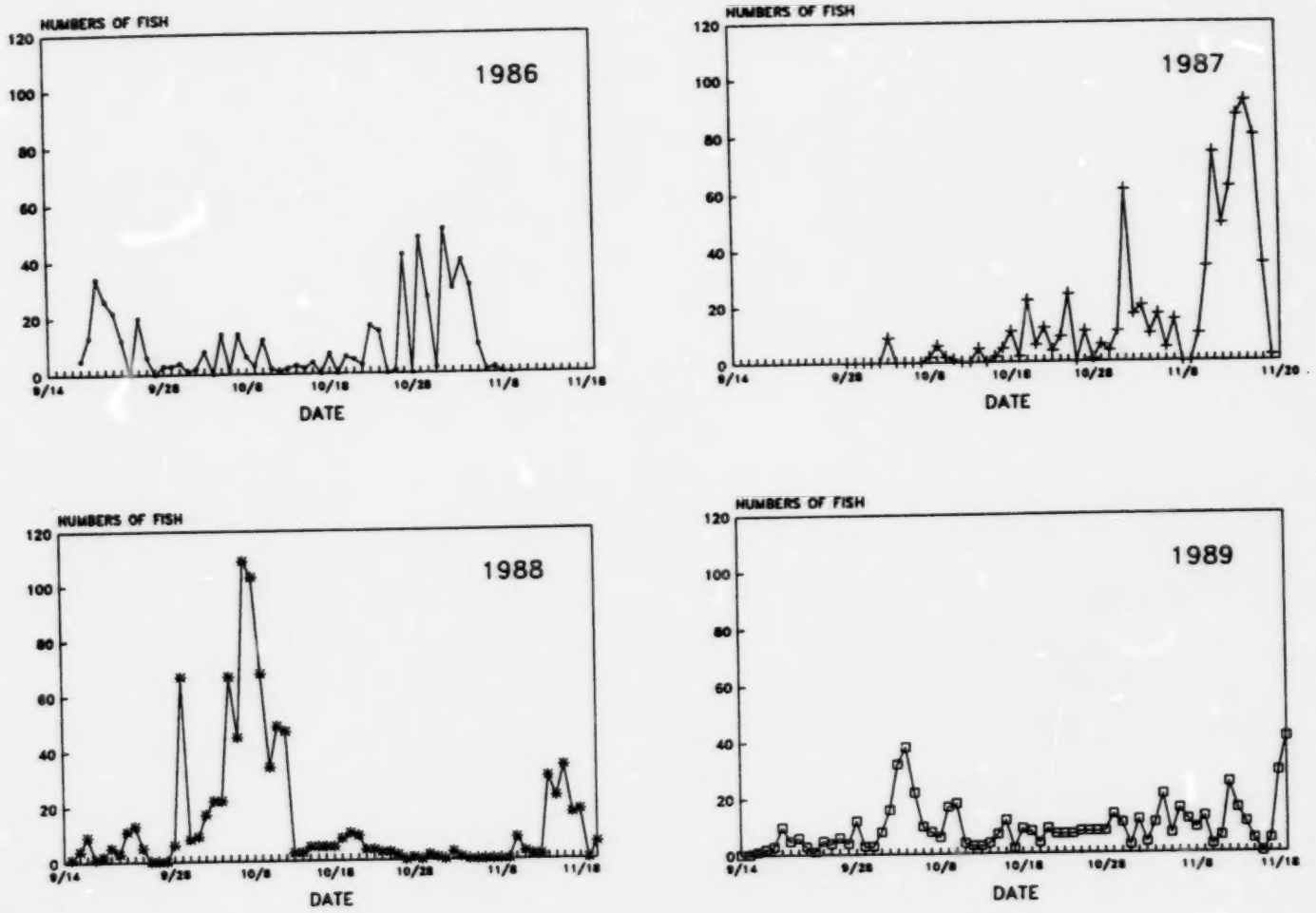

Fig. 8. Timing of steelhead through the Stamp Falls fishway, 1986 through 1989.

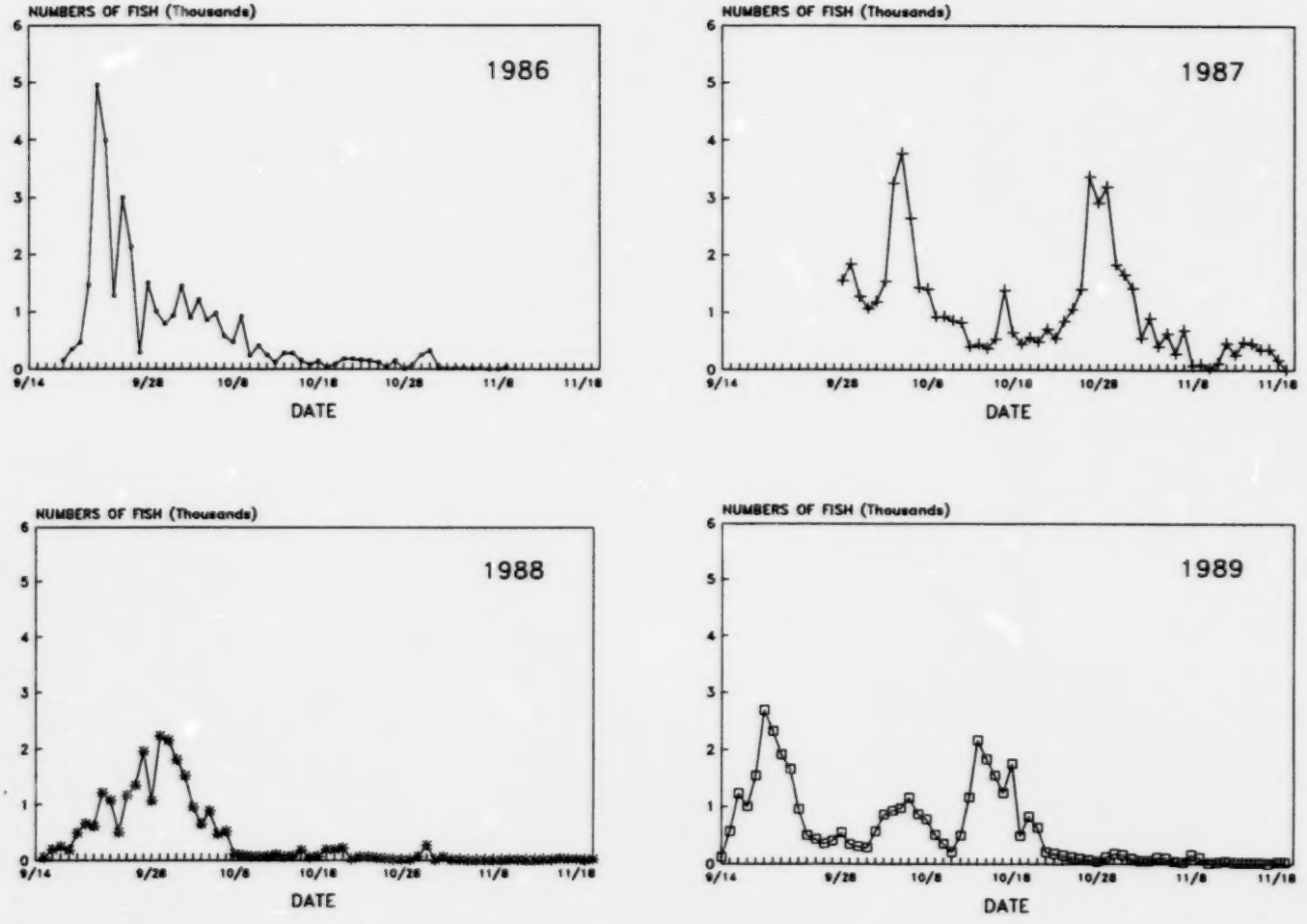

Fig. 9. Timing of sockeye salmon through the Stamp Falls fishway, 1986 through 1989.

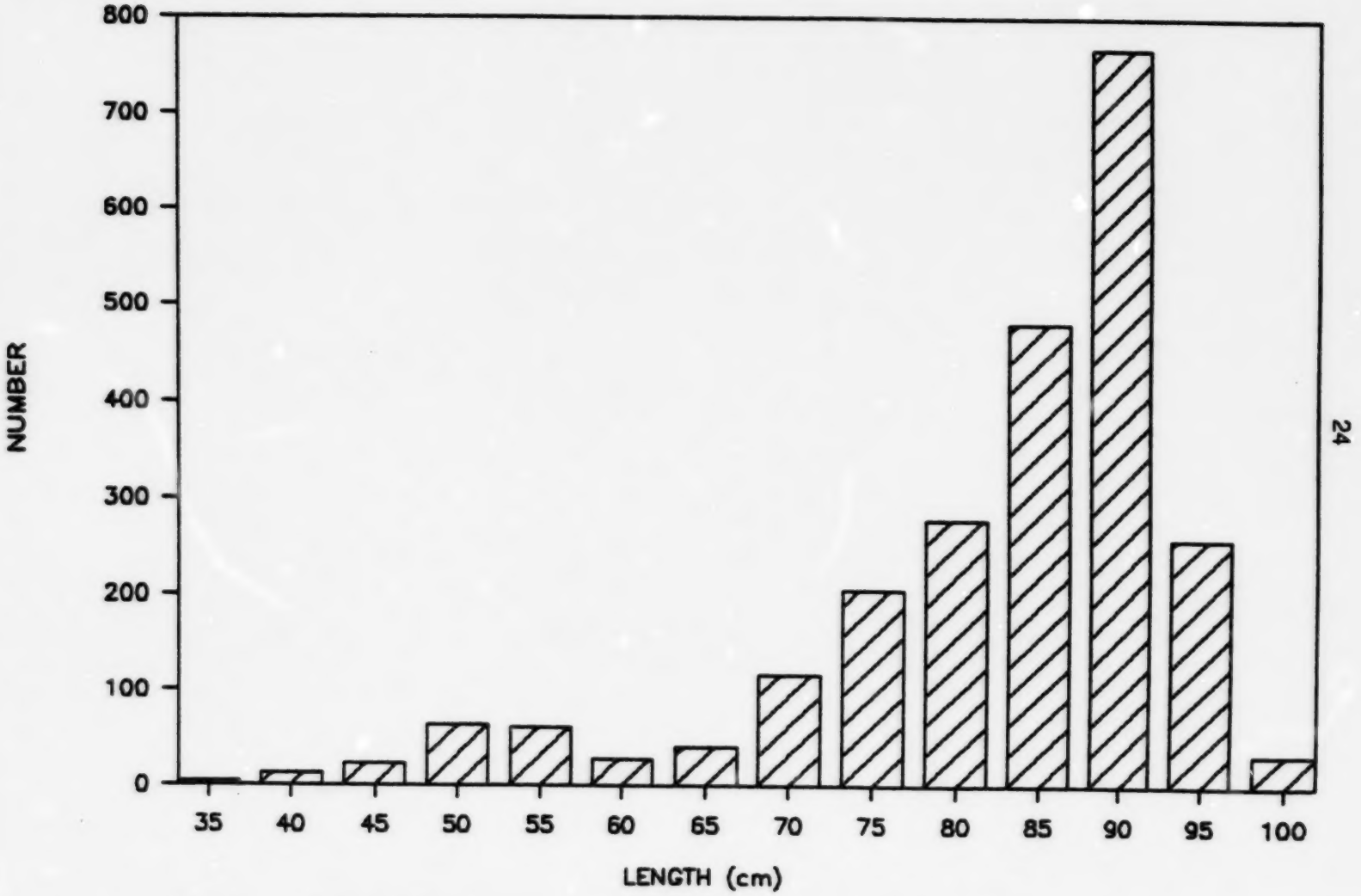

Fig. 10. Chinook length measurements between Oct. 9 and Nov. 19, 1988.

TABLES

Table 1. Numbers of male, female and jack salmon and steelhead trout passing through the Stamp Falls Fishway during the study periods in 1986-1989 [a].

Species	Year			
	1986	1987	1988	1989
Chinook salmon				
Males	15,764	41,423	N/A	N/A
Females	14,875	7,708	N/A	N/A
Unknown sex	1,970	3,478	------	------
Jacks	2,512	607	10,149	16,729
Total	35,121	53,216	76,320	79,225
Coho salmon				
Males	N/A	2,163	3,953	N/A
Females	N/A	1,729	6,641	N/A
Unknown sex	------	12,740	-----	-----
Jacks	N/A	418	1,735	4,650
Total	27,195	17,050	12,329	41,129
Sockeye salmon				
Total	33,475	55,160	24,015	38,785
Steelhead trout				
Males	N/A	85	N/A	N/A
Females	N/A	100	N/A	N/A
Jacks	N/A	1	N/A	N/A
Unknown sex	---	639	---	---
Total	561	825	947	635
Unknown salmonids	14,862	2,362	1,592	1,398

[a] Data from which this Table was derived are shown in Appendix 1, Tables 1-4.

Table 2. Mark ratio (M:UM) and percent marked (% M) for chinook and coho salmon and steelhead trout passing through Stamp Falls Fishway, 1986-1988 (mark incidence was not assessed in 1989.)[a]

Year	Chinook	% M	Coho	% M	Steelhead	% M
1986	1:79.6	1.2	N/A	-	N/A	-
1987 [b]	1:77.7	1.3	1:35.6	2.7	2.03:1	67.0
1988	1:87.3	1.1	1:61.5	1.6	N/A	-

[a] Data from which this Table was derived are shown in Appendix 1, Tables 5, 6 and 7.

[b] Mark ratios for coho salmon and steelhead trout are from the early part of the run (see p. 5 for explanation).

ıble 3. Mark ratios (M:UM) by sex, and percent marked (%M) for ıinook salmon passing through the Stamp Falls Fishway, 1986-988[a].

Sex	Mark ratio (M:UM)					
	1986	% M	1987	% M	1988	% M
ıles	1:93.7	1.1	1:78.8	1.2	1:102.4	1.0
emales	1:60.8	1.6	1:73.2	1.3	1:81.8	1.2
ıcks	1:79.4	1.2	1:60.3	1.6	1:57.0	1.7
ıknown sex	1:131.3	0.8	1:79.5	1.2	N/A	-

Data from which this Table was derived are shown in Appendix 1, Tables 5, 6 and 7.

ıble 4. Sex ratios (Male:Female) and percent males for chinook ıd coho salmon and steelhead trout passing through Stamp Falls ıshway, 1986-1988 [a].

ear	Chinook	% Male	Coho	% Male	Steelhead	% Male
986	1.06:1	51.5	N/A	-	N/A	-
987 [b]	5.37:1	84.3	1.25:1	55.6	0.85:1	45.9
988	1:1.38	42.0	1:1.68	37.3	N/A	-

Data from which this Table was derived are shown in Appendix 1, Tables 5, 6, 7 and 8.
Sex ratio data for coho salmon and steelhead trout in 1987 were from the early part of the run (see p.5). No data taken in 1989.

ıble 5. Proportional multipliers which should be applied to ımple sizes in size classes biased by the exclusion of large ısh for measurements taken in 1988 [a].

Size class (cm)	Mean proportional multiplier
85.1-90.0	1.049
90.1-95.0	1.120
95.1-100.0	1.118
100.1-105.0	1.109
105.1-110.0	1.027

Data from which this table was derived are found in Lee and Cousens (1989).

ıble 6. Sex information taken from chinook salmon ırtalities found below the Stamp Falls Fishway in 1989 [a].

Sex	Numbers	Percent
Males	1,587	51
Females	1,266	40
Jacks	266	9

Data from which this table was derived are shown in Appendix 1, Table 8.

APPENDIX 1

DATA TABLES USED IN DERIVING TEXT TABLES 1-6

Appendix 1, Table 1. Daily counts of chinook, coho, sockeye, and salmon of unknown species and steelhead trout through the Stamp Falls Fishway in 1986.

Date	CN	SX	ST	CO	UNK	Total
Sep 18	94	149	5	35	183	466
	197	342	13	448	799	1799
	438	457	34	7	54	990
	634	1469	26	836	1339	4304
	1336	4947	22	2103	1888	10296
	1307	3979	12	504	977	6779
	298	1282	0	188	489	2257
	568	3000	20	1273	285	5146
	493	2137	6	1033	140	3809
	86	285	0	12	28	411
Sep 28	272	1501	3	302	1577	3655
	677	1014	3	1442	559	3695
	643	791	4	830	622	2890
	561	934	1	1816	1085	4397
	682	1443	2	1514	439	4080
	596	894	8	1754	407	3659
	1203	1214	0	2363	332	5112
	1722	854	14	1831	250	4671
	1014	972	1	955	474	3416
	1796	577	14	804	123	3314
Oct 8	2448	471	6	607	353	3885
	2268	912	3	489	105	3777
	1394	232	12	368	52	2058
	928	404	2	265	127	1726
	892	243	1	248	119	1503
	841	116	2	202	77	1238
	928	274	3	290	233	1728
	1371	278	2	750	106	2507
	1798	153	4	236	169	2360
	650	78	0	145	183	1056
Oct 18	1375	136	7	232	46	1796
	422	31	0	91	26	570
	1048	90	6	199	68	1411
	630	173	5	187	46	1041
	701	180	3	321	75	1280
	1136	154	17	452	71	1830
	481	150	15	223	35	904
	261	123	0	146	146	676
	104	36	1	47	64	252
	289	146	42	494	52	1023
Oct 28	0	0	0	0	0	0
	75	84	48	116	105	428
	10	246	27	136	218	637
	5	318	2	326	38	689
	1	66	51	130	127	375
	5	16	30	74	21	146
	31	23	40	65	27	186
	44	20	31	75	7	177
	33	13	10	63	8	127
	14	24	1	77	4	120

Appendix 1, Table 1 (cont.) Daily counts of chinook, coho, sockeye and salmon of unknown species and steelhead trout through the Stamp Falls Fishway in 1986.

Date	CN	SX	ST	CO	UNK	Total
	1	6	2	22	7	38
Nov 8	0	0	0	0	0	0
	320	38	0	69	97	524
Totals	35121	33475	561	27195	14862	110690

Appendix 1, Table 2. Daily counts of chinook, coho, sockeye, and salmon of unknown species and steelhead trout through the Stamp Falls Fishway in 1987.

Date	CN	SX	ST	CO	UNK	Total
Sep 28	293	1556	0	1152	152	3153
	371	1846	0	1701	209	4127
	453	1284	0	1042	129	2908
	569	1073	0	1484	67	3193
	785	1185	0	1985	77	4032
	861	1544	9	1507	166	4087
	1052	3256	0	1423	178	5909
	869	3772	0	1233	221	6095
	702	2644	0	820	50	4216
	1004	1438	0	445	96	2983
Oct 8	2030	1411	2	484	32	3959
	5407	921	6	463	57	6854
	7780	929	2	423	197	9331
	4238	855	1	319	54	5467
	4293	831	0	285	120	5529
	2032	397	0	89	48	2566
	2958	447	5	119	19	3548
	2222	367	0	144	21	2754
	1963	531	2	109	95	2700
	2989	1384	5	268	30	4676
Oct 18	1720	654	11	159	49	2593
	1066	451	2	27	2	1548
	521	562	22	61	14	1180
	1118	486	6	26	2	1638
	1153	713	12	89	26	1993
	883	543	4	21	30	1481
	735	841	9	92	15	1692
	670	1063	24	99	7	1863
	413	1404	0	55	6	1878
	573	3369	11	94	24	4071
Oct 28	288	2921	1	45	10	3265
	299	3194	6	75	3	3577
	152	1830	4	36	29	2051
	271	1661	11	154	35	2132
	178	1425	61	258	20	1942
	40	551	17	29	1	638
	6[illegible]	901	20	44	[illegible]	1031
	33	411	10	15	1	470
	48	637	17	28	2	732
	25	284	5	8	0	322
Nov 7	48	687	15	25	3	778
	13	85	0	0	0	98
	15	96	0	1	0	112
	4	34	10	3	36	87
	0	115	34	18	11	178
	3	465	74	52	11	605
	2	269	49	16	1	337
	4	484	62	9	0	559
	2	455	87	10	2	556
	0	356	92	0	0	448

Appendix 1, Table 2 (cont.) Daily counts of chinook, coho, sockeye and salmon of unknown species and steelhead trout through the Stamp Falls Fishway in 1987.

Date	CN	SX	ST	CO	UNK	Total
	6	359	80	5	0	450
Nov 18	1	180	35	1	6	223
	0	3	2	0	0	5
Totals	53216	55160	825	17050	2369	128620

Appendix 1, Table 3. Daily counts of chinook, coho, sockeye, and salmon of unknown species and steelhead trout through the Stamp Falls Fishway in 1988.

Date	CN	CNJX	SX	ST	CO	COJX	UNK	Total
Sep 15	684	20	44	1	25	0	10	784
	1574	241	189	4	53	23	119	2203
	1789	414	242	9	431	77	156	3118
	1165	157	171	1	582	160	52	2288
	1864	533	485	2	682	216	105	3887
	1554	617	653	5	952	58	65	3904
	1059	457	600	3	987	152	39	3297
	3968	967	1208	11	761	34	49	6998
	1392	653	1071	13	577	67	50	3823
	775	277	491	5	362	38	26	1974
Sep 25	1499	413	1158	0	556	57	29	3712
	1176	257	1335	0	282	8	47	3105
	1496	268	1949	0	164	0	20	3897
	844	189	1056	6	67	4	5	2171
	1105	263	2228	67	76	3	38	3780
	1360	275	2146	8	36	6	26	3857
	705	332	1802	9	22	1	54	2925
	858	461	1511	17	41	2	36	2926
	329	232	950	22	11	3	13	1560
	1371	334	640	22	170	11	45	2593
Oct 5	1863	273	882	67	482	11	33	3611
	1487	94	465	45	192	14	25	2322
	1721	215	517	109	269	7	35	2873
	2070	153	108	103	132	42	23	2631
	1277	178	90	68	144	56	43	1856
	1044	127	64	34	61	37	37	1404
	1513	73	63	49	27	35	40	1800
	1001	45	64	47	38	17	55	1267
	1225	26	97	3	115	39	57	1562
	2206	39	56	3	279	35	39	2657
Oct 15	2284	111	68	5	214	46	29	2757
	2321	101	172	5	186	79	30	2894
	2362	104	51	5	171	36	15	2744
	1352	45	64	5	47	10	8	1531
	1690	91	181	8	162	34	12	2178
	1776	137	186	10	118	20	9	2256
	1979	271	219	9	214	70	8	2770
	2029	129	20	4	159	55	15	2411
	1583	111	57	4	123	17	14	1909
	1226	77	58	3	92	32	5	1493
Oct 25	1167	56	38	3	70	20	6	1360
	1224	53	29	2	54	17	4	1383
	682	27	8	0	29	15	1	762
	666	54	10	1	27	10	1	769
	605	35	11	0	42	20	4	717
	553	41	62	2	34	25	18	735
	315	27	268	1	58	9	4	682
	41	6	6	0	1	0	8	62
	126	35	54	3	55	4	10	287
	97	13	11	1	8	1	9	140

Appendix 1, Table 3 (cont.) Daily counts of chinook, coho, sockeye, and salmon of unknown species and steelhead trout through the Stamp Falls Fishway in 1988.

Date	CN	CNJX	SX	ST	CO	COJX	UNK	Total
	7	4	3	0	0	0	4	18
Nov 5	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
	15	5	3	8	45	0	5	81
	17	6	3	3	21	0	1	51
	19	2	2	2	19	0	1	45
	11	2	1	2	21	1	0	38
	12	12	9	30	10	1	0	74
Nov 15	12	4	11	23	16	0	0	66
	10	3	24	34	5	0	0	76
	7	1	18	17	5	0	0	48
	6	1	16	18	7	0	0	48
	0	0	2	0	0	0	0	2
	3	2	15	6	5	0	0	31
Totals	66171	10149	24015	947	10594	1735	1592	115203

Appendix 1, Table 4. Daily counts of chinook, coho, sockeye, and salmon of unknown species and steelhead trout through the Stamp Falls Fishway in 1989.

Date	CN	CNJX	SX	ST	CO	COJX	UNK	Total
	85	10	119	0	1	8	11	234
Sep 15	969	40	569	0	10	7	33	1628
	1433	121	1234	1	162	47	40	3038
	2143	265	999	2	533	85	89	4116
	1344	255	1540	3	755	95	6	3998
	1260	431	2687	10	895	155	1	5439
	875	535	2320	5	1383	213	0	5331
	549	543	1912	6	1257	253	1	4521
	884	225	1656	3	729	128	13	3638
	525	151	948	1	573	88	19	2305
	450	184	501	5	454	87	0	1681
Sep 25	771	657	428	4	606	317	1	2784
	770	666	352	6	717	356	1	2868
	811	628	397	4	1098	374	0	3312
	823	692	545	12	1361	273	0	3706
	771	549	339	3	1222	209	18	3111
	676	572	302	3	1242	266	25	3086
	603	477	288	8	1039	175	10	2600
	802	477	565	16	1122	155	0	3137
	1362	627	855	32	1445	183	0	4504
	2197	386	919	38	950	105	1	4596
Oct 5	2161	544	968	22	1249	127	0	5071
	2178	577	1155	10	1465	104	2	5491
	2044	615	869	8	1475	116	0	5127
	2044	484	776	6	1343	101	1	4755
	2198	519	507	17	1067	106	2	4416
	1948	543	356	18	845	91	1	3802
	1002	96	211	4	254	24	0	1601
	2533	249	499	3	749	45	0	4078
	2424	434	1169	3	1095	56	3	5184
	2003	404	2159	4	1063	52	2	5687
Oct 15	1560	328	1837	7	738	31	2	4503
	1625	202	1556	12	643	31	0	4069
	1908	158	1247	2	468	28	0	3811
	4677	412	1758	9	784	29	0	7669
	2650	123	488	8	364	4	144	3781
	2078	200	826	4	218	3	192	3521
	480	296	635	9	710	39	15	2184
	559	120	209	7	404	8	201	1508
	544	127	181	7	387	7	168	1421
	529	133	152	7	369	6	134	1330
Oct 25	514	140	124	8	352	6	101	1245
	498	147	95	8	335	5	67	1155
	483	153	67	8	317	4	34	1066
	468	160	38	8	300	3	0	977
	707	232	121	14	453	4	0	1531
	472	130	173	11	312	8	0	1106
	553	105	155	3	203	4	0	1023
	214	56	94	12	45	4	0	425
	188	44	53	4	47	0	1	337

Appendix 1, Table 4 (cont.) Daily counts of chinook, coho, sockeye, and salmon of unknown species and steelhead trout through the Stamp Falls Fishway in 1989.

Date	CN	CNJX	SX	ST	CO	COJX	UNK	Total
	228	39	51	11	45	0	0	374
	218	27	105	21	42	3	0	416
Nov 5	172	26	99	7	72	1	0	377
	101	42	46	16	50	7	0	262
	45	27	22	12	21	1	0	128
	112	60	156	9	56	4	0	397
	99	88	111	13	72	0	33	416
	25	50	12	3	34	0	0	124
	32	30	18	6	182	1	0	269
	44	27	46	25	186	2	0	330
	15	31	18	16	25	3	0	108
	13	24	21	11	17	2	4	92
Nov 15	12	18	23	5	8	1	9	76
	10	11	26	0	0	0	13	60
	11	1	8	5	11	0	0	36
	10	6	33	29	28	0	0	106
	4	0	37	41	22	0	0	104
Totals	62496	16729	38785	635	36479	4650	1398	161172

Appendix 1, Table 5. Net upstream escapement by species and/or sex, and mark status (chinook only - missing adipose fin) of salmon and steehead trout passing through Stamp Falls Fishway in 1986.

Species [c]	Movement upstream			Movement downstream			Net
	Marked	Unmarked	Marked?	Marked	Unmarked	Marked?	escapement[a]
Chinook							
F	241	14478	195	3	35	1	14875
J	23	1746	748	0	1	4	2512
M	166	1546	181	1	47	0	15764
U	10	500	547	0	2	8	1047
UF	3	392	7	0	0	0	402
UJ	0	140	2	0	0	0	142
UM	7	280	92	0	0	0	379
Totals	450	33001	1772	4	85	13	35121
Coho total[b]		27244			46		27195
Sockeye total[b]		33659			184		33475
Steelhead total[b]		565			4		561
Pink total[b]		5			0		5
Chum total[b]		67			1		66

[a] Net escapement equals movement upstream less movement downstream

[b] Mark (adipose fin missing) status was not recorded for these species

[c] Abbreviations are F = female, J = jack, M = male, U = unknown

Appendix 1, Table 6. Net upstream escapement by species and/or sex, and mark status (chinook, coho and steelhead only - missing adipose fin) of salmon and steelhead trout passing through Stamp Falls Fishway, 1987.

Species[c]	Movement upstream			Movement downstream			Net escapement[a]
	Marked	Unmarked	Marked?	Marked	Unmarked	Marked?	
Chinook							
F	117	8209	234	16	812	24	7708
J	9	676	77	0	133	22	607
M	570	44150	1508	67	4523	215	41423
U	22	2130	716	3	304	304	2257
UF	10	552	32	2	64	5	523
UJ	2	129	16	0	18	1	128
UM	9	586	51	1	69	6	570
Totals	739	56432	2634	89	5923	577	53216
Coho							
F	60	1786	89	5	188	13	1729
J	2	130	365	0	25	54	418
M	54	2321	90	7	274	21	2163
U	8	236	14301	0	106	1841	12598
UF	1	82	4	0	14	2	71
UJ	0	19	6	0	5	1	19
UM	0	69	1	0	13	3	54
Totals	125	4643	14856	12	625	1935	17052
Steelhead							
F	39	41	21	0	1	0	100
J	0	0	1	0	0	0	1
M	42	26	19	1	1	0	85
U	192	65	342	5	3	6	585
UF	16	11	6	0	1	0	32
UM	12	9	2	0	1	0	22
Totals	301	152	391	6	7	6	825
Sockeye total[b]		59878			4719		55159
Unknown total[b]		2951			589		2362

[a] Net escapement equals movement upstream less movement downstream

[b] Mark (adipose fin missing) status was not inclued for sockeye and unknown species

[c] Abbreviations are F = female, J = jack, M = male, U = unknown

Appendix 1, Table 7. Mark and sex ratios for chinook and coho salmon passing through Stamp Falls Fishway from a subsample of video tapes, 1988.

Species[b]	Mark status of ascending fish			Marked:Unmarked ratio (% : %)
	Marked	Unmarked	Total[a]	
Chinook				
F	74	6050	6124 (55.5)	1.2 : 98.8
J	8	456	464 (4.2)	1.8 : 98.3
M	43	4405	4448 (40.3)	1.0 : 99.0
Totals	125	10911	11036	1.1 : 98.9
Coho				
F	17	773	790 (45.2)	2.2 : 97.8
J	4	484	488 (27.9)	0.8 : 99.2
M	7	464	471 (26.9)	1.5 : 98.5
Totals	28	1721	1749	1.6 : 98.4

[a] Percentages by sex are shown in parentheses
[b] Abbreviations are F = female, J = jack, M = male

Appendix 1, Table 8. Male, female and jack chinook salmon encountered during a deadpitch below Stamp Falls Fishway, 1989.

Date	Number pitched	Male	Female	Jack	Sex unknown	Percent female
Oct 21	120	75	38	8	0	31.7
23	69	29	37	2	1	53.6
24	163	100	55	7	1	33.7
26	301	184	95	22	0	31.6
28	401	218	138	45	0	34.4
29	98	41	53	4	0	54.1
30	562	340	193	37	0	34.3
31	282	96	166	20	0	58.9
Nov 1	291	97	178	12	0	61.2
3	50	36	7	7	0	14.0
4	298	160	90	48	0	30.2
6	311	119	165	23	0	53.1
7	148	65	43	39	0	29.1
9	47	27	8	12	0	17.0
Total[a]	3141	1587 (50.5)	1266 (40.3)	286 (9.1)	2 (0.1)	40.3

[a] The numbers in parentheses are percentages of the total deadpitch

APPENDIX 2

A DISCUSSION OF ERROR IN THE 1987 STUDY

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INTRODUCTION

Three data sources were analyzed for error from the 1987 video experiment. The first set includes the original readings from the complete video tape record. These data were compared with a second set obtained from the operation of a fish trap. The times of the trap opening and closing were matched with corresponding times on the original tape readings and the number, species and sex were compared between data sets. The third data set represents a second reading of selected video tapes. These data were used to assess reader error and bias.

This section of the report first describes the data records and fields. It then presents analysis of the comparison between the video tape data and the fish trap data. The data from the reread tapes is then compared to the data from the original reading. Finally difference between the various readers is calculated and assessed.

Data description

Each fish observed on the video tapes generated a unique data record. Each record contained the following fields:

Date - The date the tape was recorded.

Time - The approximate time that fish passed the camera.

Tape - The number of the video tape.

Species - A species code for each fish. The following codes were used:

- CM - chum salmon
- CN - chinook salmon
- CO - coho salmon
- PK - pink salmon
- ST - steelhead trout
- SX - sockeye salmon
- T - other Trout
- UCM - unknown but probably chum salmon
- UCN - unknown but probably chinook salmon
- UCO - unknown but probably coho salmon
- UPK - unknown but probably pink salmon
- UST - unknown but probably steelhead trout
- USX - unknown but probably sockeye salmon
- UT - unknown but probably trout
- U - species unknown

Sex - A code for each sex as follows:

- F - female
- M - male
- J - jack
- UF - unknown sex probably female
- UM - unknown sex probably male
- UJ - unknown sex probably jack
- U - sex unknown

Mark - To indicate if the adipose fin was present or missing. The following codes were used:
Y - Adipose fin was present
N - Adipose fin was missing
U - Unable to determine presence or absence of adipose fin.

UpDn - A U (up) or a D (down) were used to designate the direction of travel.
Reader - The initials of the person that read the tape.
Page - The page number of the data entry sheets.

The data taken from the trap counts had the following fields: Date, time, species, sex, mark. Usually the species and sex were known, however, sometime fish escaped the trap without identification and sometimes without being counted.

Data preparation

The data were keypunched and "cleaned". Cleaning was done by resolving invalid field codes and by various cross-tabulations for obvious conflicting fields, such as date and tape number. The data base was searched for invalid codes or data and each nonconforming record was reviewed and corrected. This procedure does not ensure total accuracy of the data entry process. However, given the nature of the data, this procedure was adequate.

The data from the video tape readings were corrected for up-and-down stream movement of the fish. The number of records with a U in the UpDn field were reduced by a corresponding number of records with D in the UpDn field. This procedure assumed that each fish seen travelling down stream had previously been counted going up stream.

Appendix 2, Table 1 presents the total counts by species read from the video tapes and transcribed by the video tape readers. The number up, down and corrected are shown. In addition the relative number of unknown and unknown but probable species are also shown.

Calibrations with Trap Data

Calibration events were defined as comparison of counts from the video tapes with counts from a trap in the fishway. These counts were conducted at the same time. The purpose of this procedure was to test the accuracy of the video tape data by comparing selected video counts with direct visual counts in the trap. Data from the trap were matched with the original video tape data by extracting the video tape counts for the corresponding date and time. Appendix 2, Table 2 presents the list of calibration events.

Except for calibration event numbers 36, 43 and 44 there were records of fish passage from the video tape for all events. The corresponding dates and times for these missing events were not in the data base. Further investigation of the data indicated that the tapes were either blank or black during these episodes. Therefore, these data were left out of the analysis.

Appendix 2, Table 3 through Appendix 2, Table 5 present the comparisons of fish counts from the video tapes and the traps for chinook, coho and sockeye salmon respectively. Only one steelhead was collected in the trap and it was also seen on the video tapes. No other species were present in the trap or identified on the tapes during a calibration event.

For the counts of chinook, coho and sockeye salmon a calibration factor between the video tape readings and the trap counts was calculated (Appendix 2, Table 6.) A proportional difference between the count of the species in the trap and the data from the video tapes was calculated for each calibration event. These proportional differences were treated as sample observations of the calibration factor.

Many of the events had a zero count for one of the species. However, there were fish present in all calibration events. Therefore, all 43 calibration events were used as samples in the calculations of the mean and variance of the differences.

The proportional or ratio differences were assumed to be sampled from a student-t distribution. Confidence intervals (95%) were also calculated using this distribution and are presented in Appendix 2, Table 6 in addition to maximum and minimum population estimates.

Calibration factors were also calculated for the sex ratios of chinook salmon. Sex identification for chinook salmon was very poor (Appendix 2, Table 3), however, a calibration factor could be calculated (Appendix 2, Table 6). No sex identification was possible or reliable for coho or sockeye salmon.

For this analysis the proportion of each sex (males, females and jacks) and the variance in the proportions was calculated independently. A sample of ratio differences in the sex proportions was calculated between the tape and the trap data for each sex. A mean calibration and 95% confidence intervals was also calculated for each sex proportion. The size of the 95% confidence intervals

(Appendix 2, Table 6) support the conclusion that sex identification with the video tape method is very unreliable.

Treatment of Unknowns

In this analysis the unknown but probable species records (species codes UCN, UCO and USX) were treated as known species. The remaining unknown species in the calibrations events were then compared with the trap data. Appendix 2, Table 7 presents events where there were unknown species from the readings of the video tapes. As there were only 5 such events and a large variability in the species mix in the trap data no reliable method for allocating unknown species could be developed. However, the occurrence of unknown species in the total data set represents less than 2% of the total number of fish counted. In light of the size of the calibration factor and confidence intervals presented in Appendix 2, Table 6 these unknown fish are insignificant in relation to the noise or error in the estimates of total escapements.

Tape Rereads

In addition to calibrating the video data with trap data an attempt was made to measure the degree of error in the process of reading the tapes. Twenty-six of the tapes, representing approximately 20% of the fish, were reread by different readers. A comparison of the two readings and an assessment of reader bias were analyzed (Appendix 2, Tables 8 and 9).

Unfortunately, the method of recording the times for the fish passage differed between the two readings. This fact made it impossible to match the times recorded for the passage of an individual fish from one reading with the times for the same fish from the other reading. A fish by fish comparison of the two data sets was not possible, instead a tape by tape analysis was done.

Appendix 2, Table 8 presents the counts of chinook, coho and sockeye from the two readings of the tapes. As with the calibration analysis with the trap data, the unknown but probable species were included as known species.

The tape by tape comparisons resulted in large differences in fish counts. The total count from both readings for chinook salmon were remarkably similar (1% difference). However, the mean of the absolute relative tape to tape difference was much larger (chinook salmon 16.5%, coho salmon 38.6% and sockeye salmon 8.5%).

Appendix 2, Table 9 presents the average proportional differences (summing pluses and minuses) between the two readings and the 95% intervals of the sampled distribution. These differences were constructed by treating the counts from each tape as a single sample, providing 26 samples of proportionate differences.

Given the results of the calibrations analyses (with the trap data) regarding sex identification and the difficulty in comparing the two readings no analysis or comparison of sex ratios was attempted.

Reader Bias

The original readings together with the reread tapes provided an opportunity to assess reader bias. One test of bias involved comparing total counts of fish from the two readings of the tapes. Appendix 2, Table 10 presents the counts by readers (who read 3 or more tapes) and their differences from all other readers that read the same tapes. There were some consistent differences amongst readers but none of the difference were significantly different from zero (to the .05 level). Given the lack of statistical difference in the total count and the degree of error in species and sex identification present in the calibrations no attempt was made to identify bias in the species or sex identifications.

Recommendations

The method of counting fish with a video camera shows some promise at providing a reasonable estimate of the total number of fish. The counts of chinook salmon from the video tapes corresponded reasonably well with the calibration events from the trap data. However, the inconsistency between the two readings of the same tapes is disquieting.

From the results of these analyses one can conclude that the video system provides total chinook salmon escapements estimates with an error of approximately +/- 10% (Appendix 2, Table 6). Using this method to assess other characteristics such as sex ratios or marked to unmarked ratios cannot be recommended.

The counts of coho and sockeye salmon were much less accurate. This may be because the smaller fish escaped the trap without being counted. If they did escape the trap then the video camera may provide a better method for these species. However, the data analyzed here does not provide enough clarification of the accuracy of the video tape verses the trap.

There does not seem to be a significant reader bias. However if the data from the tapes had been transcribed with times that were consistent from reading to reading, enabled a fish by fish comparison, then certain biases about species identification could have been assessed.

TABLES

Appendix 2, Table 1. Total counts of fish by species up, down and corrected from original tape readings.

Species	Movement		Corrected	Including unknown but probable
	Up	Down		
CM	86	12	74	79
CN	59,812	6,596	53,216	53,650
CO	19,651	2,601	17,050	17,352
PK	19	6	13	17
ST	844	19	825	909
SX	59,875	4,715	55,160	55,415
T	179	23	156	176
U	1,498	306	1,192[a]	
UCM	5	0	5	
UCN	548	114	434	
UCO	379	77	302	
UPK	8	4	4	
UST	91	7	84	
USX	320	65	255	
UT	21	1	20	

[a] Some fish could not be speciated with any certainty and are called "unknowns". The unknowns comprised (1192 ÷ 127,686) x 100 = 0.93% of the total known plus unknown species counts and (2,296 ÷ 128,790) x 100 = 1.78% if counts of fish with unknown but probable species status are included.

Appendix 2, Table 2. Calibration events.

Calib. number	Tape no.	Date	Start time	End time
1	006	30-Sep-87	10:19:23	10:20:19
2	006	30-Sep-87	10:27:23	10:31:32
3	010	02-Oct-87	8:59:39	9:05:44
4	010	02-Oct-87	9:17:16	9:24:05
5	010	02-Oct-87	10:24:17	10:30:19
6	010	02-Oct-87	10:51:09	10:51:20
7	010	02-Oct-87	11:11:11	11:11:20
8	010	02-Oct-87	12:43:29	12:43:50
9	010	02-Oct-87	13:06:49	13:08:16
10	016	05-Oct-87	9:07:50	9:08:46
11	016	05-Oct-87	9:20:19	9:21:16
12	016	05-Oct-87	9:31:10	9:32:09
13	016	05-Oct-87	9:42:45	9:43:17
14	020	07-Oct-87	10:23:22	10:23:57
15	020	07-Oct-87	10:40:35	10:48:05
16	024	09-Oct-87	8:45:58	8:46:13
17	024	09-Oct-87	9:05:17	9:07:42
18	024	09-Oct-87	9:18:15	9:19:34
19	024	09-Oct-87	9:27:47	9:28:53
20	024	09-Oct-87	10:46:09	10:46:28
21	024	09-Oct-87	10:55:00	10:56:34
22	033	13-Oct-87	8:55:18	8:59:12
23	033	13-Oct-87	9:09:53	9:10:22
24	033	13-Oct-87	9:20:55	9:23:00
25	033	13-Oct-87	9:31:41	9:33:42
26	033	13-Oct-87	9:43:46	9:44:26
27	033	13-Oct-87	13:47:03	13:48:12
28	033	13-Oct-87	13:54:03	13:54:23
29	033	13-Oct-87	14:07:56	14:09:42
30	033	13-Oct-87	14:23:13	14:27:43
31	033	13-Oct-87	14:39:40	14:40:00
32	035	14-Oct-87	8:52:10	8:53:55
33	035	14-Oct-87	9:03:15	9:05:08
34	035	14-Oct-87	9:13:42	9:16:02
35	035	14-Oct-87	9:26:00	9:26:18
36	054	21-Oct-87	9:00:14	9:00:34
37	060	23-Oct-87	9:05:19	9:09:58
38	060	23-Oct-87	9:22:40	9:23:16
39	069	26-Oct-87	11:15:24	11:18:44
40	069	26-Oct-87	11:02:42	11:04:05
41	075	28-Oct-87	8:52:27	8:52:39
42	082	30-Oct-87	15:22:34	15:23:11
43	090	02-Nov-87	8:57:27	8:58:05
44	090	02-Nov-87	9:10:28	9:11:44
45	099	06-Nov-87	10:03:04	10:05:28
46	103	09-Nov-87	8:42:59	8:45:28

Appendix 2, Table 3. Number of chinook salmon in calibration samples.

Calib.	Total		Males		Females		Jacks		Unknown sex	
number	Tape	Trap	Tape	Trap	Tape	Trap	Tape	Trap	Tape	Trap
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	1	1	1	1	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	2	2	1	0	1	2	0	0	0	0
6	1	0	1	0	0	0	0	0	0	0
7	2	2	1	0	1	2	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	1	1	1	0	0	1	0	0	0	0
11	1	1	0	0	0	0	0	1	1	0
12	2	2	1	1	0	1	0	0	1	0
13	0	0	0	0	0	0	0	0	0	0
14	5	5	5	4	0	0	0	1	0	0
15	0	0	0	0	0	0	0	0	0	0
16	0	5	0	4	0	1	0	0	0	0
17	1	1	1	0	0	1	0	0	0	0
18	3	2	3	2	0	0	0	0	0	0
19	3	3	3	3	0	0	0	0	0	0
20	6	4	4	2	1	2	0	0	1	0
21	2	2	1	1	1	1	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0
23	3	3	3	3	0	0	0	0	0	0
24	2	1	2	0	0	1	0	0	0	0
25	6	5	6	4	0	1	0	0	0	0
26	6	6	6	4	0	2	0	0	0	0
27	1	1	1	0	0	0	0	0	0	0
28	3	4	3	1	0	3	0	0	0	0
29	7	7	7	3	0	4	0	0	0	0
30	2	2	1	2	0	0	0	0	1	0
31	4	4	4	2	0	2	0	0	0	0
32	4	4	3	2	1	2	0	0	0	0
33	1	1	0	0	1	1	0	0	0	0
34	2	2	1	1	1	1	0	0	0	0
35	4	4	4	4	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0
Total	75	75	64	44	7	28	0	2	4	0

Appendix 2, Table 4. Number of coho salmon in calibration samples.

Calib.	Total		Males		Females		Jacks		Unknown sex	
number	Tape	Trap	Tape	Trap	Tape	Trap	Tape	Trap	Tape	Trap
1	0	2	0	0	0	2	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	1	1	0	0	0	1	0	0	1	0
4	2	2	0	1	0	1	0	0	2	0
5	1	1	0	0	0	1	1	0	0	0
6	4	3	0	2	0	1	0	0	4	0
7	6	4	0	0	0	4	0	0	6	0
8	2	2	0	1	0	1	0	0	2	0
9	6	5	0	1	0	4	0	0	6	0
10	0	0	0	0	0	0	0	0	0	0
11	1	1	1	0	0	0	0	0	0	1
12	1	0	0	0	0	0	0	0	1	0
13	0	0	0	0	0	0	0	0	0	0
14	1	0	0	0	1	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0
16	0	1	0	0	0	1	0	0	0	0
17	0	1	0	0	0	0	0	0	0	1
18	2	1	0	0	0	1	0	0	2	0
19	1	2	0	1	0	1	0	0	1	0
20	2	0	0	0	0	0	0	0	2	0
21	0	0	0	0	0	0	0	0	0	0
22	0	1	0	0	0	1	0	0	0	0
23	2	2	0	0	0	2	0	0	2	0
24	0	0	0	0	0	0	0	0	0	0
25	0	0	0	0	0	0	0	0	0	0
26	1	0	0	0	0	0	0	0	1	0
27	0	0	0	0	0	0	0	0	0	0
28	1	0	0	0	0	0	0	0	1	0
29	0	0	0	0	0	0	0	0	0	0
30	3	0	0	0	0	0	0	0	3	0
31	0	0	0	0	0	0	0	0	0	0
32	1	1	0	0	0	1	0	0	1	0
33	1	0	0	0	0	0	1	0	0	0
34	1	0	0	0	0	0	1	0	0	0
35	0	0	0	0	0	0	0	0	0	0
37	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0
40	0	0	0	0	0	0	0	0	0	0
41	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0
45	0	0	0	0	0	0	0	0	0	0
46	0	0	0	0	0	0	0	0	0	0
Total	40	30	1	6	1	22	3	0	35	2

Appendix 2, Table 5. Number of sockeye salmon in calibration samples.

Calib.	Total		Males		Females		Jacks		Unknown sex	
number	Tape	Trap	Tape	Trap	Tape	Trap	Tape	Trap	Tape	Trap
1	1	3	0	2	0	1	0	0	1	0
2	1	2	0	1	0	1	0	0	1	0
3	1	1	0	1	0	0	0	0	1	0
4	3	4	0	2	0	2	0	0	3	0
5	0	0	0	0	0	0	0	0	0	0
6	1	1	0	1	0	0	0	0	1	0
7	1	1	0	0	0	1	0	0	1	0
8	3	4	0	2	0	2	0	0	3	0
9	2	2	0	1	0	1	0	0	2	0
10	8	6	0	2	0	4	0	0	8	0
11	6	4	0	0	0	4	0	0	6	0
12	14	11	0	4	0	7	0	0	14	0
13	14	9	0	5	0	4	0	0	14	0
14	2	1	0	0	0	1	0	0	2	0
15	9	7	0	3	0	3	0	0	9	1
16	0	0	0	0	0	0	0	0	0	0
17	1	0	0	0	0	0	0	0	1	0
18	3	2	0	1	0	1	0	0	3	0
19	3	1	0	0	0	1	0	0	3	0
20	2	3	0	2	0	1	0	0	2	0
21	0	0	0	0	0	0	0	0	0	0
22	1	0	0	0	0	0	0	0	1	0
23	2	2	0	0	0	2	0	0	2	0
24	0	0	0	0	0	0	0	0	0	0
25	4	2	0	0	0	1	0	0	4	1
26	1	2	0	0	0	2	0	0	1	0
27	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0
29	0	0	0	0	0	0	0	0	0	0
30	3	3	0	1	0	2	0	0	3	0
31	0	0	0	0	0	0	0	0	0	0
32	1	0	0	0	0	0	0	0	1	0
33	0	0	0	0	0	0	0	0	0	0
34	3	2	0	1	0	1	0	0	3	0
35	1	1	0	0	0	1	0	0	1	0
37	3	1	0	1	0	0	0	0	3	0
38	4	4	0	3	0	1	0	0	4	0
39	1	1	0	1	0	0	0	0	1	0
40	15	14	0	3	0	11	0	0	15	0
41	10	9	0	7	0	1	0	0	10	1
42	6	6	0	4	0	2	0	0	6	0
45	6	7	0	5	0	2	0	0	6	0
46	12	8	0	7	0	1	0	0	12	0
Total	148	124	0	60	0	61	0	0	148	3

Appendix 2, Table 6. Comparison of video tape reading and trap counts.

Species	Proportional differences (%)			Total escapement estimates			
	Diff.	Min.	Max.	Orig.	Calib.	Max.	Min.
Chinook[a] Total	4.6	-4.2	13.5	53,216	50,768	55,451	46,032
Males	18.8	4.5	33.1	41,423	31,418	39,028	23,809
Females	-18.2	-28.9	-7.5	7,708	17,393	23,087	11,699
Jacks	-2.9	-7.6	1.9	602	2,150	4,651	(404)
Coho total	11.3	-5.3	27.9	17,050	15,123	17,954	12,293
Sockeye total	12.5	0.7	24.2	55,160	48,265	54,774	41,811

[a] Sex ratios from original video tape recordings were: Male 77.8%, Female 14.5%, Jacks 1.1% and Unknown 6.5%

Appendix 2, Table 7. Calibration of unknown species on tape to data from trap.

Calib. number	Unknown species	Species mix from trap data (%)		
		chinook	coho	sockeye
1	3	0	50	50
3	1	0	0	0
8	2	0	0	100
12	3	0	25	75
16	6	83	17	0

Appendix 2, Table 8. Fish counts by species from the original and reread tapes.

Tape no.	Chinook			Coho			Sockeye			Unknown	
	Original	Reread	% diff	Original	Reread	% diff	Original	Reread	% diff	Original	Reread
2	14	19	-36	11	6	45	54	60	-11	8	0
6	505	479	5	1171	1051	10	1198	1197	0	75	28
7	357	334	6	518	512	1	641	616	4	42	38
8	338	307	9	1279	1288	-1	858	873	-2	34	41
17	737	743	-1	744	721	3	2194	2369	-8	38	18
25	1342	1172	13	174	129	26	395	322	18	11	11
29	3692	4162	-13	253	226	11	706	633	10	37	7
34	1459	1676	-15	63	55	13	267	243	9	38	0
35	3024	2593	14	126	139	-10	425	398	6	0	29
59	119	119	0	4	4	0	227	221	3	0	5
72	430	313	27	108	81	25	1527	1391	9	0	16
74	68	49	28	6	3	50	528	493	7	0	2
76	62	66	-6	5	4	20	462	471	-2	0	1
85	168	133	21	67	57	15	719	648	10	22	18
91	21	20	5	2	5	-150	170	189	-11	0	2
92	24	20	17	31	27	13	342	308	10	2	2
102	16	12	25	8	13	-63	338	341	-1	0	2
103	26	27	-4	1	0	100	197	191	3	0	0
104	8	12	-50	3	7	-133	41	67	-63	31	23
105	0	0	0	30	13	57	166	142	14	0	43
106	3	2	33	47	35	26	411	428	-4	7	1
107	0	0	0	0	2	0	27	24	11	0	4
108	0	0	0	1	0	100	8	8	0	0	0
109	1	0	100	9	8	11	109	112	-3	0	0
110	1	1	0	9	7	22	163	163	0	0	3
122	5	5	0	2	4	-100	153	151	1	0	3
Tot.	12420	12264	1	4672	4397	6	12326	12059	2	345	297
Mean total diff:			7			4			0.4		
Mean absolute:			17			39			9		

Appendix 2, Table 9. Mean differences between original and reread tapes.

	Percent difference	95% Confidence interval
Chinooks	6.9	+/- 10.8%
Coho	3.5	+/- 23.2%
Sockeye	0.4	+/- 5.9%

Appendix 2, Table 10. Comparison of total counts by reader with all other readers of same tape.

Reader AD		
Tape number	Count	Difference
29	5042	348
35	3582	419
72	2082	263
91	220	23
102	380	6
103	227	6
105	232	-5
109	152	0
110	193	-6
Mean % diff.		4.5

Reader BF		
Tape number	Count	Difference
6	2757	-192
59	350	-1
107	33	3
122	186	-1
Mean % diff		0.3

Reader GS		
Tape number	Count	Difference
8	2512	-25
34	1828	-164
74	549	-55
76	542	12
85	878	-111
92	375	-38
104	96	-26
107	30	-3
110	199	6
Mean % diff.		8.3

Reader S		
Tape number	Count	Difference
2	85	-2
7	1570	66
17	3891	157
34	1992	164
91	197	-23
103	221	-6
108	8	-2
109	152	0
122	187	1
Mean % diff		2.7

Reader RB		
Tape number	Count	Difference
8	2537	25
25	1634	-288
35	3163	-419
76	530	-12
106	539	-16
Mean % diff		-7.0

Reader J		
Tape number	Count	Difference
7	1504	-66
25	1922	288
72	1819	-263
92	413	38
105	237	5
Mean % diff		1.5

Reader VW		
Tape number	Count	Difference
2	87	2
85	989	111
104	122	26
106	555	16
Mean % diff		9.4

Reader BY		
Tape number	Count	Difference
29	4694	-348
102	374	-6
108	10	2
Mean % diff		3.7